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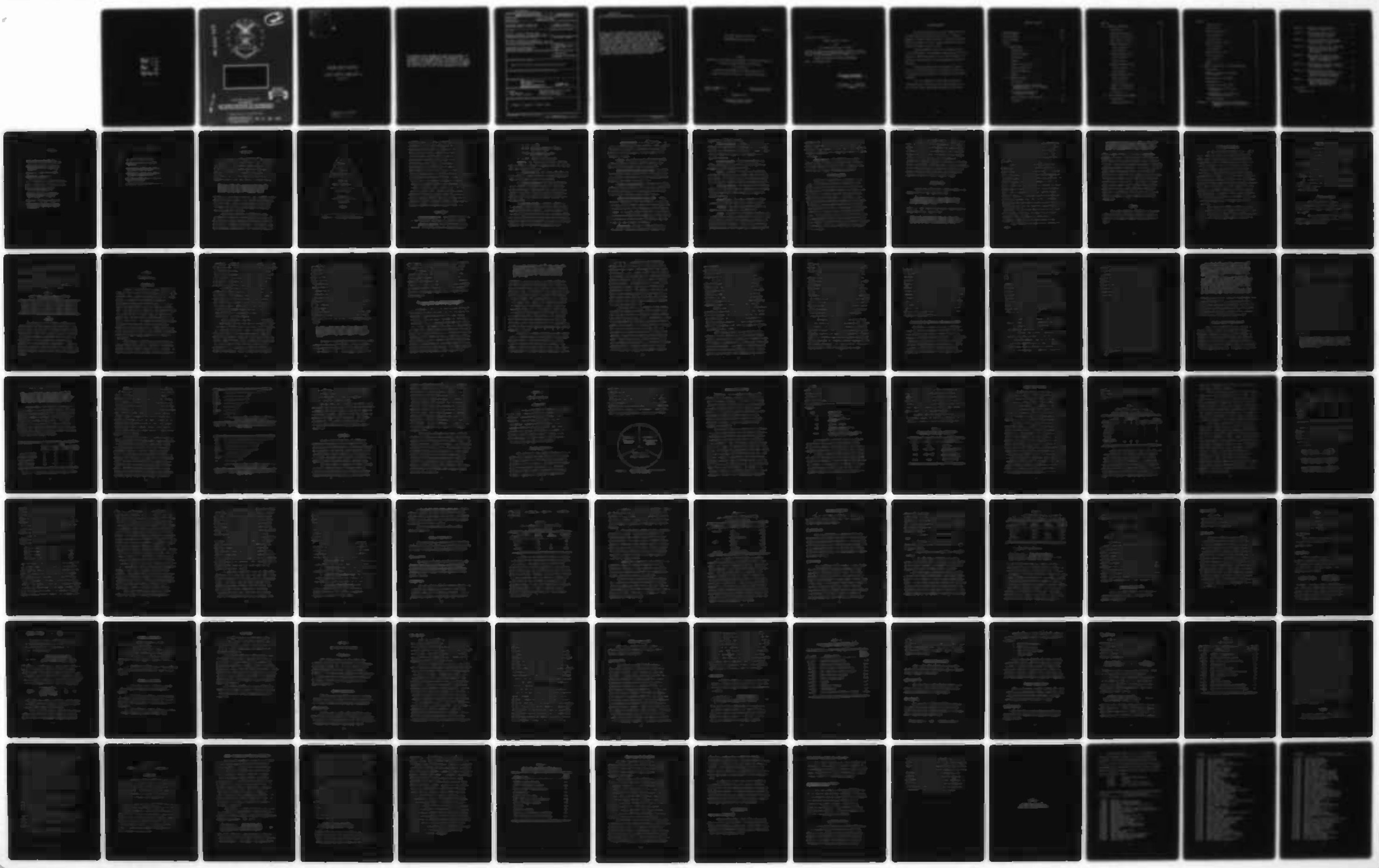

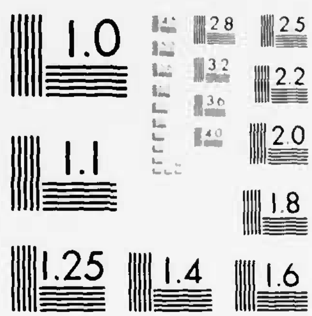

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THE SURGE CAPACITY OF THE U.S.
INDUSTRIAL BASE: A MACRO VIEW

Brian R. Koechel, Captain, USAF
Timothy W. Brown, 1st Lieutenant, USAF

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Concern about the defense industrial base and its ability to respond to increased demand for goods produced for the Department of Defense during a surge has become an important issue with Headquarters United States Air Force. This thesis project was an effort to identify key industries supporting DOD aerospace commodity requirements and to assess the identified industries' ability to surge from a capacity utilization view. Ninety-six industries were identified as the manufacturing industries supporting the production of aerospace goods purchased by the Department of Defense. Three of those industries lacked the production capacity to respond to a surge, while eight other industries were identified as vulnerable to potential bottlenecks during a surge.

LSSR 69-83

THE SURGE CAPACITY OF THE U.S. INDUSTRIAL BASE: A MACRO VIEW

A Thesis

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Logistics Management

By

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September 1983

This thesis, written by

Captain Brian R. Koechel

and

1st Lieutenant Timothy W. Brown

has been accepted by the undersigned on behalf of the faculty of the School of Systems and Logistics in partial fulfillment of the requirements for the degree of

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CHAPTER I

INTRODUCTION

The purpose of the United States Armed Forces is to provide for the security and defense of the United States. A key factor in the successful accomplishment of this objective is a strong defense industrial base capable of supplying large amounts of weapons and equipment to the military services in a short period of time (14:125). The defense industrial base (see Figure 1-1) can be defined as:

> that part of the total privately-owned and goverment owned industrial production and maintenance capacity of the U.S. expected to be available to manufacture and repair items required by the military services during an emergency [34:7].

Consequently, the defense industrial base encompasses those public and private sectors of the economy that Department of Defense (DOD) industrial preparedness planners expect will supply and maintain military weapons and hardware during an emergency situation.

Although the Department of Defense has major investments in production and maintenance facilities, the DOD primarily purchases weapons and equipment produced in the private or commercial marketplace. For example, total DOD procurement expenditures for the 1982 fiscal year were

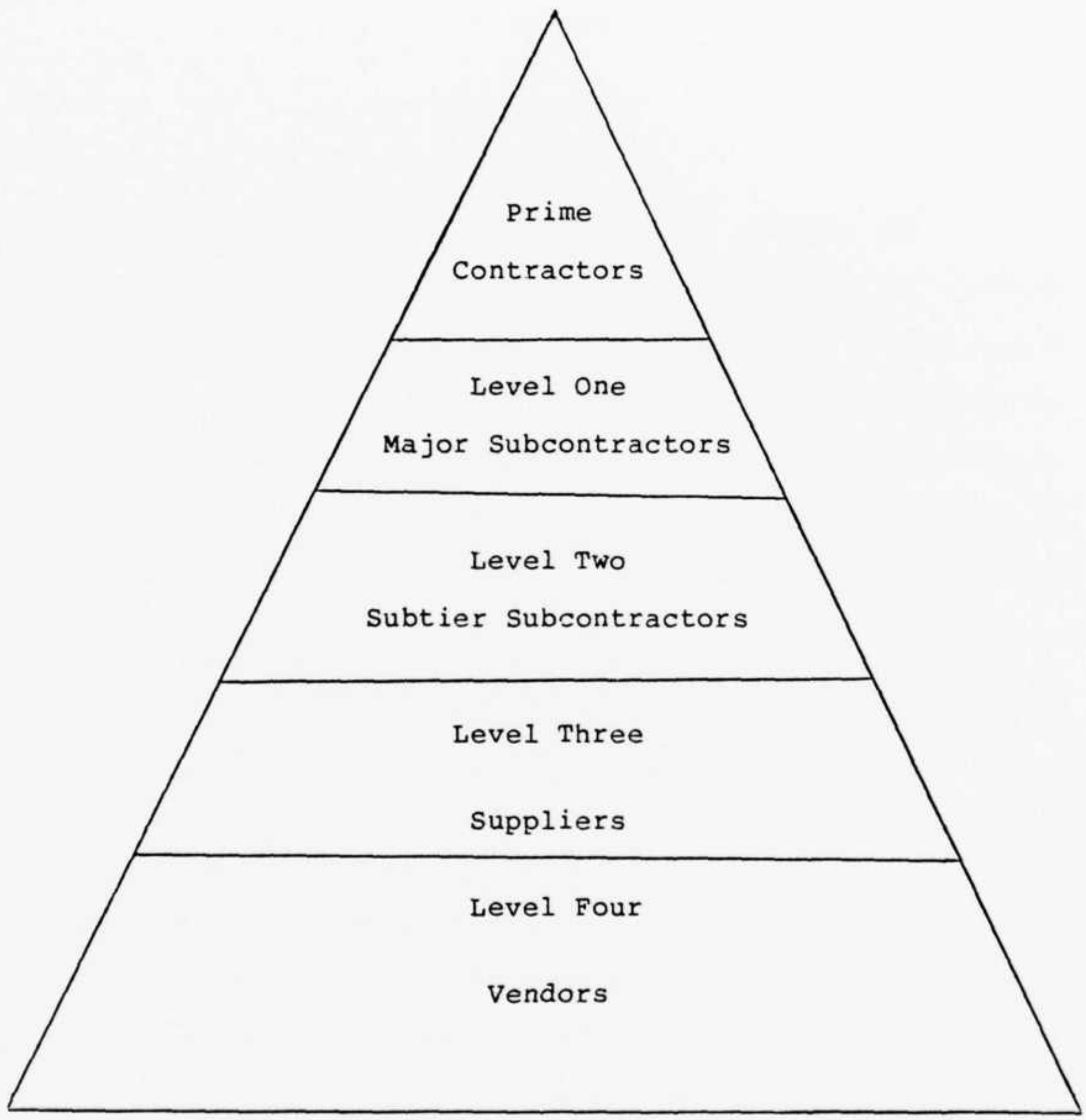

Figure 1-1 The Defense Industrial Base

approximately $34 billion. The Department of Defense estimates its procurement expenditures will increase to approximately $40 billion in fiscal year 1983 (1:172). Since the private sector comprises the largest segment of the defense industrial base, the DOD must view profit and business stability as the primary incentives for attracting private industry into the defense marketplace. Unfortunately, the steady growth of commercial markets, when compared to the cyclical nature of defense business, and the post-Vietnam era of decreasing defense expenditures has made defense business unattractive to many private firms (10:25). For example, the number of companies involved in aerospace production has decreased from 6,000 in 1967 to less than 3,500 in 1980 (37:12). The decreasing number of private firms involved in defense related production has raised a concern among senior DOD officials that the defense industrial base may no longer have the production capacity required to rapidly produce additional military weapons and equipment during a crisis (3:1).

Definitions

Aerospace Commodities: The production output from the four industries comprising the aerospace industry.

Aerospace Industry: Firms whose primary work or production is classified under the following Bureau of

Economic Analysis Input-Output codes:

1. 60.0100 Aircraft
2. 60.0200 Aircraft and Missile Engines and Engine Parts
3. 60.0400 Miscellaneous Aircraft and Missile Parts
4. 13.0100 Complete Guided Missiles

Capacity: The fixed amount of plant, machinery, and the number of personnel a company plans to do business with over a period of one year.

a) Current Capacity: The actual production rate of an industry. Current capacity is normally measured in terms of the number of units being produced.

b) Practical Capacity: The maximum production rate an industry can feasibly operate at, taking into account unavoidable interruptions such as lost time for repairs of machinery, delays in delivery of materials or supplies used in the production process, and the lack of customer orders.

c) Preferred Capacity: Preferred capacity is an intermediate level of production rate between current capacity and practical capacity. Preferred capacity is the rate at which manufacturers strive to produce because it is the production rate at which profits are maximized. Preferred capacity is expressed as the ratio of the current production rate to the preferred production rate.

c) Excess Capacity: The difference between an industry's preferred and current capacity. Excess capacity represents the amount of an industry's fixed plant and machinery that is available to increase production in response to a surge.

Crisis: Any situation where additional defense items are needed, excluding conflicts requiring full mobilization and declared national emergencies.

Defense Industrial Base Lower Levels: All levels of the defense industry below the prime contractor level. This includes all subcontractors, sub-tier subcontractors, suppliers, and vendors (see Figure 1-1).

Industrial Responsiveness: The extent the defense industrial base can respond to any conflict, including wars or declared emergencies, as perceived by DOD officials concerned with industrial preparedness planning.

Industrial Preparedness Program (IPP): Plans, actions, or measures for the transformation of the industrial base, both government-owned and civilian-owned, from its peacetime activity to the emergency program necessary to support the national defense objectives. IPP includes such measures as modernization, expansion, and preservation of the production facilities and contributory items and services for the planning with industry.

Mobilization: The act of preparing for war or other national emergencies through the assembling and

organizing of national resources.

National Emergency: A condition declared by the President or Congress which authorizes certain emergency actions to be undertaken in the national interest. These actions include the partial or total mobilization of national resources.

Prime Contractor: Any source intended to be a direct recipient of a contract or purchase order to be awarded by a DOD contracting activity.

Sector: A segment or division of the national economy that produces like or similar goods and services. For example, the aircraft sector of the economy consists of all firms and industries producing completed aircraft.

Sectorial Analysis: An analysis of the production capacity of a distinct segment or segments of the defense industrial base which produce material in support of national security.

Subcontractor: Any source intended to receive a contract or purchase order from a prime contractor.

Supplier: Any source who supplies material or items to a prime contractor or subcontractor.

Surge: The ability of the defense industrial base to rapidly meet production requirements for military items with existing facilities in a peacetime environment (no declared national emergency). Only existing peacetime program priorities would be available to obtain materials,

components, and other industrial resources necessary to support accelerated production requirements. For the purposes of this research, a surge means the DOD demand for aerospace commodities will increase 100 percent in response to a crisis.

Surge Capacity: The availability of excess capacity and/or the ability to expand current capacity or acquire additional resources (tools, equipment, plant space) for the purpose of increasing production.

Problem Statement

Attrition of subcontractor involvement, rising costs, and increasing production leadtimes are three salient factors often cited by senior DOD officials as indications that the defense industrial base may not have the ability to respond to and meet DOD peacetime and wartime production requirements. Additionally, the decreasing defense procurement expenditures of the post-Vietnam era has discouraged many firms from upgrading their equipment, facilities, and manufacturing technology, resulting in a serious decline in production capacity (23:1). The perception among senior DOD officials is that sufficient capacity exists at the large prime contractor level; however, serious deficiencies in production capacity are believed to exist at the subcontractor and supplier levels (10:125).

Interviews with Major Donald R. Fowler, Industrial Base Responsiveness Officer, HQ USAF/RDCM, Mr. Ronald Vawter of the Mobilization Concept Development Center, Industrial College of the Armed Forces, and a review of recent literature indicate the ability of the aerospace industry to surge production may be hindered by insufficient production capacity, especially at the lower levels of the defense industrial base. Thus, an assessment of the production capacity involving all levels of the defense industrial base supporting the production of aerospace commodities during a surge is needed.

Justification

A 1980 House Armed Service Committee Report of the Defense Industrial Base Panel found that:

> The industrial base is not capable of surging production rates in a timely fashion to the increased demands that could be brought on by a national emergency [9:11].

Further, Mr. Dale Church, former Deputy Undersecretary for Defense Acquisition, noted in 1979:

> While prime contractors in the base have sufficient or excess production capacity, there are very serious deficiencies at the first, second, third and so forth tiers of subcontractors [9:12].

Accordingly, the key element to increasing production may not be the prime contractor's capacity, but the capacity of the lower level subcontractors and suppliers whom may already be producing at full capacity (25:19). This lack of production capacity could result in serious production bottlenecks during a crisis (18:197).

Instability in the defense spending has also contributed to the decline in production capacity at the lower levels of the defense industrial base. For example, in the post-Vietnam era of declining defense expenditures, increasing numbers of prime contractors are performing work formerly subcontracted to other companies (7:49). As a result, lower level subcontractors are leaving the defense marketplace for markets that are more stable and profitable. This is evidenced by the fact that the number of companies involved in aerospace production has declined by more than 40 percent since 1967 (37:12). In summary, compared to other businesses, defense contracting is viewed by many subcontractors and suppliers as less stable, less predictable, and less financially attractive than commercial business. Therefore, the ability of the defense industrial base to respond to a surge seems to be inadequate, especially at the lower levels (39:191).

In an interview with Major Fowler, HQ USAF/RDCM, he stated:

> A comprehensive study on the capacity of the lower tier sectors of our aerospace defense economy to respond to a production surge is needed. Such a study would be beneficial to our senior decision-makers in understanding the surge problem [13].

Further, Jacques Gansler, in his book, The Defense Industry, believes a sectorial analysis focusing on the lower levels of the defense industrial base, instead of individual firms would provide early warnings of impending production problems (14:281-282). A sectorial analysis is accomplished by aggregating data for all industries involved in the production of a commodity and then studying the inputs and outputs of the industries involved over a fixed period of time (19:321). Accordingly, research assessing the capacity of the defense industrial base, especially the lower levels, should be undertaken to determine if the defense industrial base has sufficient capacity to support a surge in demand for aerospace commodities.

Purpose

This study attempted to determine if the defense industrial base has sufficient capacity to support the production of aerospace commodity requirements during a surge.

Scope and Limitations

This study involved an analysis of the manufacturing industries within the defense industrial base which support the production of aerospace commodities. Consequently, specific capabilities of individual firms were not assessed. Also, this research is limited to situations requiring a surge and not a full-scale mobilization. Mobilization was not addressed because the economy would be subject to a drastic shift in priorities as the government would assume control over the economy's production through powers granted by the Defense Production Act of 1950. In contrast to a full mobilization, surge relates to a peacetime increase in military production. During peacetime, a company is free to pursue commercial as well as military business and the government has no means of forcing manufacturers to increase their military production.

This research was further limited by the data. The most accurate, current, and complete data used is limited to the 1972 Bureau of Economic Analysis input-output tables and the Census Bureau's 1980 capacity utilization rate tables.

Research Objectives

1. To identify the manufacturing industries within the defense industrial base required to increase production due to a surge in aerospace defense commodity requirements.

2. To determine the increase in output required from each manufacturing industry to support a surge in aerospace defense commodity requirements.

3. To determine the amount of excess capacity available to each manufacturing industry to support a surge in aerospace defense commodity requirements.

4. To identify the manufacturing industries within the defense industrial base which lack the excess capacity or are the most vulnerable to a surge in aerospace defense commodity requirements.

Research Questions

1. Which manufacturing industries within the defense industrial base will be required to increase production due to a surge in aerospace defense commodity requirements?

2. What is the required increase in output of each manufacturing industry supporting a surge in aerospace defense commodity requirements?

3. What is the excess capacity of the manufacturing industries supporting a surge in aerospace defense commodity requirements?

4. What is the maximum increase in output that can be achieved by each manufacturing industry supporting a surge in aerospace defense commodity requirements and which industries are most vulnerable to a surge?

TABLE 1-1

Relationship between Research Objectives and Research Questions

Research Objective #1 relates to Research Question #1.
Research Objective #2 relates to Research Question #2.
Research Objective #3 relates to Research Question #3.
Research Objective #4 relates to Research Question #4.

Summary

The decline of the U.S. defense industry at the subcontractor level has caused concern among senior level DOD officials. Specifically, the defense industrial base, especially the lower levels, may not be able to respond to DOD aerospace commodity requirements during a surge. An integral part of a well-planned and organized surge capability is called industrial preparedness. Chapter II contains a review of current literature on the state of the defense industrial base and the DOD Industrial Preparedness Program.

CHAPTER II

LITERATURE REVIEW

Introduction

Chapter I has detailed the perceptions senior DOD officials have about the current condition of the defense industrial base. Before proceeding with a more in-depth study, it is necessary to describe the Industrial Preparedness Program (IPP) currently used by the DOD to assess the surge capabilities of the defense industrial base. The purpose of the Industrial Preparedness Program is to plan and sustain enough industrial capability to support this country's needs for defense equipment in a time of crisis (4:6). The Industrial Preparedness Program includes such measures as industrial modernization, expansion, and the preservation of production facilities. Since the inception of IPP in 1920, Industrial Preparedness Planning has been limited primarily to the concept of mobilization.

Mobilization is defined as the rapid expansion of military production by the U.S. economy to meet material demands during a national emergency (39:3). However, the need to plan for a rapid increase in military production in

a peacetime environment was first realized during the 1973 Arab-Israeli War. In 1973, the U.S. was unable to increase its production of tanks to replace those lost by Israel. This led to the concept of surge (4:3). Surge is defined as the ability of the defense industrial base to rapidly meet military production requirements with existing production facilities in a peacetime environment (33:12).

According to the literature, the problems of supporting a mobilization and a surge are closely related. For example, if the defense industrial base can support a rapid expansion in military production during peacetime, then production increases for mobilization should also be realized (39:2). Hence, IPP has a significant role in assessing the defense industrial base's ability to surge production in a peacetime environment, as well as mobilizing for a national emergency.

While IPP plays an important role in determining U.S. surge capability, the condition of the defense industrial base is probably the most important factor affecting the United States' ability to surge. The Defense Industrial Base Panel of the House Armed Services Committee, Ninety-Sixty Congress, expressed a major concern about the defense industrial base's lack of capability in responding to crisis situations other than these requiring full mobilization (37). Congress is primarily interested in surge for two reasons. First, the DOD must be prepared

to respond to a wide variety of peacetime and wartime contingencies. For example, the U.S. could conceivably be involved in a high intensity nuclear war lasting a few weeks or a low intensity conventional war lasting several years. In either case, the pre-conflict warning time could be extremely short; therefore, the U.S. must maintain a defense industrial base with enough production flexibility to respond rapidly to DOD requirements in a wide variety of peacetime and wartime environments (4:16-19). The second reason Congress is concerned with the surge capability of the defense industrial base is the deterrence of war. Congress and many DOD officials believe that an economy capable of rapidly producing large amounts of military equipment will deter potential adversaries from attacking the United States. As Dr. Fred Ikle, former Director of the U.S. Arms Control and Disarmament Agency, stated:

> We need to improve the capacity of American industry to mobilize rapidly for a major expansion in defense production. That in itself might act as a potential deterrent to major aggression; if it does not, we would at least have the means to respond [17:84].

The ability of the defense industrial base to surge production relies on three factors: (1) plant capacity; (2) availability of labor; and (3) the availability of critical materials (4:ix). This research focuses on the

plant capacity of those manufacturing industries supporting the production of aerospace commodities during a surge.

In essence, this literature review focuses on IPP and the defense industrial base, as they are both cornerstones to assessing the United States' surge capability and production capacity. Review is presented through (1) a historical view of the relationships between the defense industrial base and IPP; (2) the current DOD industrial preparedness program; and (3) current views on surge capacity.

The Relationships of Industrial Preparedness and the U.S. Defense Industrial Base

Bordered by ocean on the east and west and friendly countries to the north and south, the U.S. has rarely felt threatened or experienced conflict with other nations on her soil. With this secure attitude, the literature indicates the U.S. was unprepared when World War I began (37:7; 11:28). For example, lead times were twelve months for small arms, eighteen months for ammunition, and thirty months for artillery pieces (37:7). Fortunately, this slow response by U.S. industries was not a significant factor in the outcome of the war. However, military strategists did realize a problem existed in increasing production to meet military mobilization requirements. For example, Benedict Crowell, Assistant Secretary of War, wrote in 1919:

> Our strategic equipment included plans ready drawn for the mobilization of men . . . this equipment included no plan for the equally important and equally necessary mobilization of industry and production of munitions, which proved to be the most difficult phase of the actual preparation for war [8:18].

Consequently, Congress passed the National Defense Act of 1920 which required the establishment of an industrial planning organization within the Office of the Assistant Secretary of War. The purpose of this organization was to develop contingency plans for the future procurement of military equipment and the mobilization of U.S. industry in the event of war. These initial industrial mobilization plans were the predecessor to today's Industrial Preparedness Plans (37:7). The industrial mobilization plans designated approximately 10,000 industrial plants as planned producers of war materials. The industrial mobilization plans were accomplished every three years from 1930 to 1939, and assisted the U.S. in expanding its industrial base to meet wartime requirements upon entering World War II (11:30).

Although the industrial mobilization plans helped the U.S. industrial base increase production more rapidly during World War II than during World War I, overall industrial mobilization planning was inadequate. For example, industrial planners such as Leo A. Codd, Executive Vice-President of the Army Ordinance Association, observed

in 1941 that "military production could be advanced anywhere from 6 to 18 months if our war plants were in readiness today [11:34]." Even though the Unites States had undergone at least eighteen months of partial mobilization before entering World War II, it took approximately twenty-one months for the country to reach its maximum production output. Once mobilized, U.S. production was "staggering"; however, there was much "fumbling and improvisation" (25:27). One reason it took the U.S. so long to reach maximum production was that there was no identifiable defense industry at the beginning of World War II and the U.S. had to convert commercial factories into military facilities (37:8).

After World War II, the industrial base reverted to producing commercial products. The attitude of DOD officials was that the U.S. monopoly on nuclear weapons would deter any future wars (37:8). Consequently, industrial preparedness was ignored by government officials. However, the detonation of a nuclear device by the Soviet Union and the escalation of the Cold War led to the enactment of the National Security Act of 1947 and the subsequent creation of the National Security Resources Board. The National Security Resources Board was the first permanent executive agency in the federal government dedicated solely to peacetime mobilization planning. Its functions were to advise the President concerning

the coordination of military, industrial, and civilian mobilization, establishing reserves of strategic and critical materials, and the strategic location of industries and other production facilities (25:28).

In 1950, President Truman replaced the National Security Resources Board with the Office of Defense Mobilization. The Office of Defense Mobilization was responsible for developing an industrial base that could respond to a wide variety of national emergencies and contingencies. Basically, the Office of Defense Mobilization performed the same functions the Federal Emergency Management Agency is responsible for today (25:28).

Another significant event occurring in 1950 was the enactment of the Defense Production Act of 1950. The Act gives the president the authority to mobilize the country's resources during a war. The Act also implemented the Defense Priorities System which requires manufacturers to place critical defense items ahead of commercial items on the production line (37:8-9).

Mobilization planning, the stockpiling of war material, and the emergence of an identifiable defense industry after World war II resulted in an industrial base that generally responded well to increased DOD requirements during the Korean War. For example, a "planned producer structure" for tanks was activated by the DOD. However, none of the thousands of tanks produced by Ford, General

Motors, and Chrysler were deployed because they were never needed. The main point is that the tanks were available within the time frame requested by the DOD (27:115).

The Vietnam War provided the next test for the defense industrial base. During the Vietnam War, the defense industrial base demonstrated a capability to meet DOD production requirements as evidenced by the huge quantities of defense material supplied by U.S. manufacturers. In fact, according to General Henry A. Miley, President of the American Defense Preparedness Association, "the tonnage shipped in the peak month to Vietnam exceeded that of World War II and the Korean War combined (22:56)." This was accomplished even though U.S. industrial mobilization was essentially performed against a "business-as-usual" peacetime setting, and no "planned-producer structures" were activated (27:41).

The defense industrial base's ability to surge was first tested during the 1973 Arab-Israeli War. During this conflict, the U.S. tried to increase the production of tanks to support Israel. The prime contractor had the necessary resources and capacity to increase the output of tanks, but a forging subcontractor producing castings and turrets was unable to increase production because his plant was already operating at full capacity (4:3). This led to the government's emphasis on planning for a surge.

Today, industrial preparedness responsibilities are dispersed among the Federal Emergency Management Agency, the Department of Commerce, and the Department of Defense. The Federal Emergency Management Agency is responsible for overall industrial preparedness. The Department of Commerce is responsible for ensuring that (1) adequate supplies of industrial resources are available to meet military wartime needs, and (2) industrial resources can be expanded in a national emergency (25:30). The Department of Defense is responsible for ensuring that sufficient industrial capacity exists to meet national requirements for defense systems, equipment, and spare parts in the event of a war or crisis. To carry out these responsibilities, the DOD implemented the Department of Defense Industrial Preparedness Program in 1975 (9:47).

The Current DOD Industrial Preparedness Program

The purpose of the DOD Industrial Preparedness Program is to provide a means for the defense industrial base to rapidly expand military production during an emergency in an orderly fashion (35:1-2202). This program is coordinated by officials of the Office of the Undersecretary of Defense/Research and Engineering. However, the primary responsibility for answering questions regarding the surge capability of the defense industrial

base rests with the individual services. Currently, each service can plan for the emergency production of no more than 2,000 items including thirty-five major weapon systems. These items include avionics systems, ordnance parts, and aircraft spares (36:2).

Production planning for individual pieces of equipment is probably the most important part of the industrial preparedness program. However, limiting the program to approximately 2,000 items for each service does not permit production planning for all military equipment that might be used in a crisis. Therefore, a system to assign priorities for selecting items is published in DODI 4005.3. According to DODI 4005.3, items to be planned for must be essential to combat operations and must meet one or more of the following criteria:

1. A long lead time.

2. Requires the development of new or additional capacity to meet the emergency production requirements.

3. Requires continuous contractor surveillance to ensure emergency requirements are met.

4. Critical labor skills or specialized production equipment is needed to produce the item (4:7-8).

With this guidance, each service attempts to determine what items having one or more of the above characteristics will be required in large quantities in the event of an emergency. In addition, estimated wartime

consumption figures and estimated repair times are used to calculate the rate a given item will be used during an emergency. This quantity is then compared with the quantity available from inventory and anticipated normal production to determine if any advance planning actions should be taken for the additional production of the items during an emergency (11:66-67). This selection process requires industrial preparedness planners to exercise considerable discretion in making choices about the large numbers of items that pass these initial tests. Once the service chooses the items to plan for, contractors producing those items are asked to provide data regarding their ability to meet increased production requirements. Contractor participation in the Industrial Preparedness Program is voluntary and they are not compensated for their participation. Therefore, there is suspicion among many DOD officials that the data may not be accurate. However, the data supplied by the contractor is used by the DOD to determine what kind of reserve production capacity is available and what kinds of advance planning actions should be funded to ensure the capacity is adequate (13:9). The literature indicates that this system is not working and contributes little to the goal of reducing the risk of inadequate production capacity in times of crisis (4:25). For example, according to a 1980 Defense Science Board Report:

The planning base is much too large to handle with the limited funds and personnel available. Further, the truly critical items have not been identified. The process is keyed to the DD Form 1519, "Industrial Preparedness Program Production Planning Schedule." Indicative of the lack of commitment in the process is a statement on the form as follows:

"The signatures hereon in no way bind the named firm(s) nor the Government in any contractual relationship nor is acceptance to be construed as an agreement by industry to maintain production capability as indicated herein." Clearly, there is very little motivation on the part of the contractor to take the forms seriously.

One critic has commented that since the Department of Defense doesn't pay for the effort, they are getting just what they pay for [37:1607-1608].

An understanding of the DOD Industrial Preparedness Program is important because it is the current method used to assess the surge capacity of the defense industrial base and many DOD officials associated with IPP are concerned that insufficient production capacity exists, especially at the lower levels of the defense industrial base.

Current Views on Surge Capacity

Most of the literature reviewed indicates the U.S. defense industrial base has insufficient capacity to adequately respond to a surge in military demand. For example, the "Nifty-Nugget" DOD mobilization exercise conducted in the fall of 1979 indicated the defense industrial base could not respond rapidly to accelerated military requirements (37:10). In addition, the Defense

Industrial Base Panel of the House Armed Service Committee reported in 1980 that the "industrial base is not capable of surging production rates in a timely fashion to the increased demands that could be brought on by national emergency [37:11]."

A major reason cited for the United State's lack of surge capability is inadequate production capacity, especially at lower levels of the defense industrial base. Industrial preparedness studies indicate that little is known about the support capabilities of second and third tier subcontractors. For example, a major problem with the current DOD industrial preparedness program is that it addresses only prime contractors. This fact, coupled with increasing production lead times and declining U.S. manufacturing productivity has raised the concern among senior DOD officials that insufficient production capacity exists at the lower levels of the defense industrial base. This is evidenced by the following statement by Dr. Richard D. DeLauer, Undersecretary of Defense for Research and Engineering:

> The current condition of the U.S. industrial base can be characterized as unbalanced. While sufficient capacity generally exists at the large prime contractor level to support Defense programs, deficiencies exist at the subcontractor and vendor levels [10:25; 40:2].

In addition, Jaques Gansler states,

> Most of the lead time, single source and similar problems which limit defense capacity are at the lower tiers. This, a key finding of the Defense Science Board, was confirmed by several recent TASC (The Analytical Sciences Corporation) studies of lead times and industrial responsiveness [32:14].

Another report citing production capacity as a limiting factor in our surge capability was a 1980 study by Coopers and Lybrand which found that the production lead times for a number of items had increased significantly between 1978 and 1980 (see Figure 2-1). The study indicates that the increases in production lead time appeared to be caused by limited production capacity due to a simultaneous increase in commercial and military demand for the items being studied (37:1483).

	Weeks		
	1978	1980	Percent Increase
Titanium Forgings	33	117	84
Aluminum Forgings	32	81	49
Titanium Plate	25	92	37
Steel Forgings	36	82	46

Figure 2-1 Examples of Lead Time Increases 1978-1980

Another factor indicative of declining capacity is the decline in U.S. productivity over the past twenty years. According to General Alton D. Slay, former Commander, Air Force Systems Command: "In 1977, we were at 1.8 productivity growth rate. That dropped to 0.5 in 1978 and minus eight-tenths of 1 percent in 1979 [37:480]." Unfortunately, the U.S. is dead last in productivity growth when compared to other industrialized western nations. For example, Figure 2-2 compares the percent average annual productivity growth rate for the total economies of seven industrialized nations from 1960 to 1979. Also, Figure 2-3 indicates that the U.S. percent average annual manufacturing growth rate is the lowest among all industrialized western nations (38:481).

Even though the majority of literature states the defense industrial base probably cannot respond adequately to increased demand for military items during a surge or mobilization, a 1977 study by the Rand Corporation presented a different view of the defense industrial base. The Rand Corporation was primarily concerned with assessing the capacity of the lower levels of the defense industrial base and the ability of the lower levels to respond quickly to increased military production requirements. The Rand researchers concluded that the lower levels of the industrial base had enough excess capacity to double defense related output within a year (4:12).

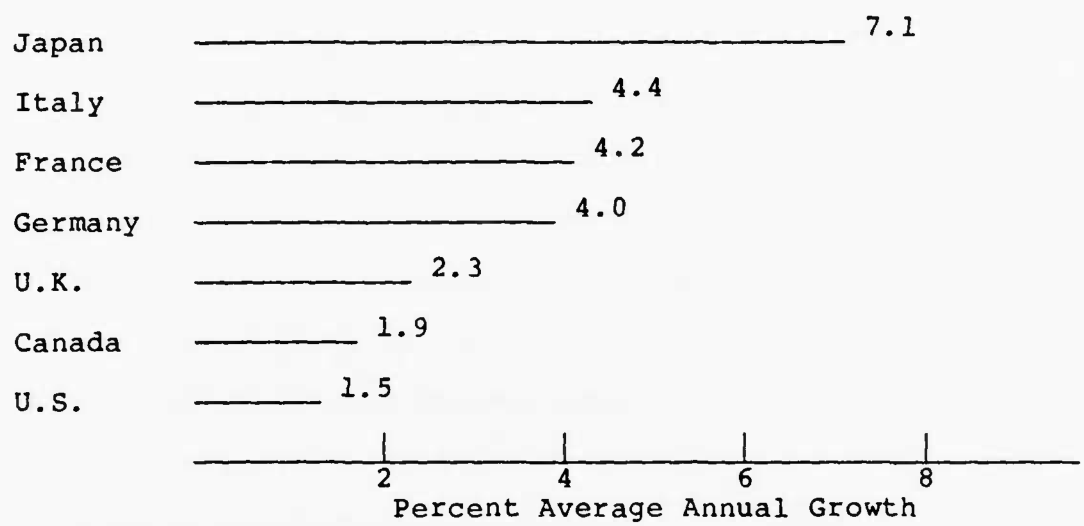

Figure 2-2 International Productivity Ranking 1960-1979 (Total Economy)

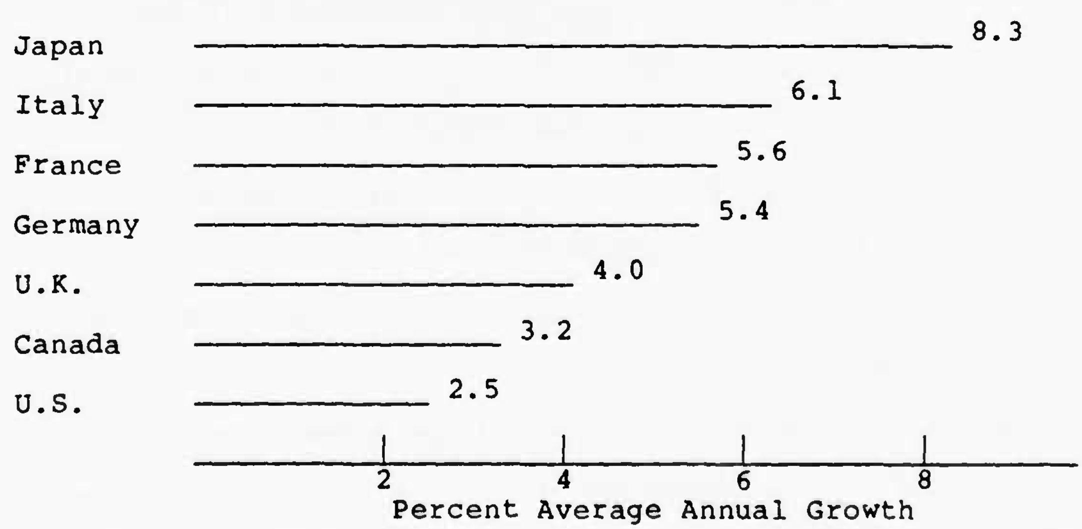

Figure 2-3 International Productivity Ranking 1960-1979 (Manufacturing)

This Rand study was the only empirical study encountered in the literature search, as well as the only study that specifically addressed the production capacity of all levels of the defense industrial base.

The Rand study used an economic methodology called input-output analysis and used the 1963 and 1967 Department of Commerce Input-Output Tables to forecast the impact of a 100 percent increase in demand for military items on the manufacturing segment of the U.S economy. The concepts associated with input-output analysis and the use of the input-output tables will be explained more fully in Chapter III.

Conclusion

As seen from the literature, the Industrial Preparedness Program has had a six decade history of inefficiency and ineffectiveness. The defense industrial base, meanwhile, has undergone large fluctuations from a non-identifiable defense industry prior to World War II, to a strong, responsive base through the Vietnam War, to today's allegedly inadequate defense industrial base.

The first segment of Chapter II related the history of the U.S. economy's ability to increase military production during periods of war, and how the economy's responsiveness led to the evolution of the current DOD

Industrial Preparedness Program. The second segment of Chapter II described the current Industrial Preparedness Program which is used by the DOD to assess the ability of the defense industrial base to surge military production. Finally, the last segment of Chapter II related the current view held by senior DOD officials that the defense industrial base cannot surge due to insufficient production capacity, especially at the lower levels of the defense industrial base. Two primary indicators of inadequate capacity are increasing production lead times and declining productivity. Finally, the results of a 1977 Rand study was presented. The Rand researchers concluded that there is sufficient capacity at all levels of the defense industrial base.

This research addressed the current perceived problem of insufficient defense industrial base capacity, especially at the subcontractor and supplier levels. The research questions, developed in Chapter I and highlighted throughout the literature review, were addressed through a methodology called input-output analysis. Input-output analysis is essentially an economic methodology that identifies the interrelationships between industries involved in the production of an economy's output. Chapter III explains input-output analysis in more detail and describes the methodology used to answer research questions one through four.

CHAPTER III

RESEARCH METHODOLOGY

Introduction

The previous two chapters described the background on the current state of the defense industrial base and Industrial Preparedness Planning as related to surge capability. The the need to determine if the lower levels of the defense industrial base can support a surge in aerospace production was also discussed. This chapter describes the universe, the population of interest for the research, and input-output analysis. Further, as part of the methodology, the chapter details the data collection and analysis process used in this research.

Universe Description

The universe for this research consisted of the 496 industries and commodities identified by the U.S. Bureau of Economic Analysis in the 1972 Detailed Input-Output Structure of the U.S. Economy. The universe was divided into three populations (see Figure 3-1). Population I consisted of those industries comprising the aerospace industry. Population II consisted of manufacturing

industries critical to the support of a surge in aerospace commodity production. Together, Populations I and II comprise the aerospace defense base. Population III consisted of those industries having a minimal impact on the surge capability of the aerospace industry. Figure 3-1 summarizes the relationship between the three populations comprising the universe for this research. Populations I and II are the populations of interest to this effort.

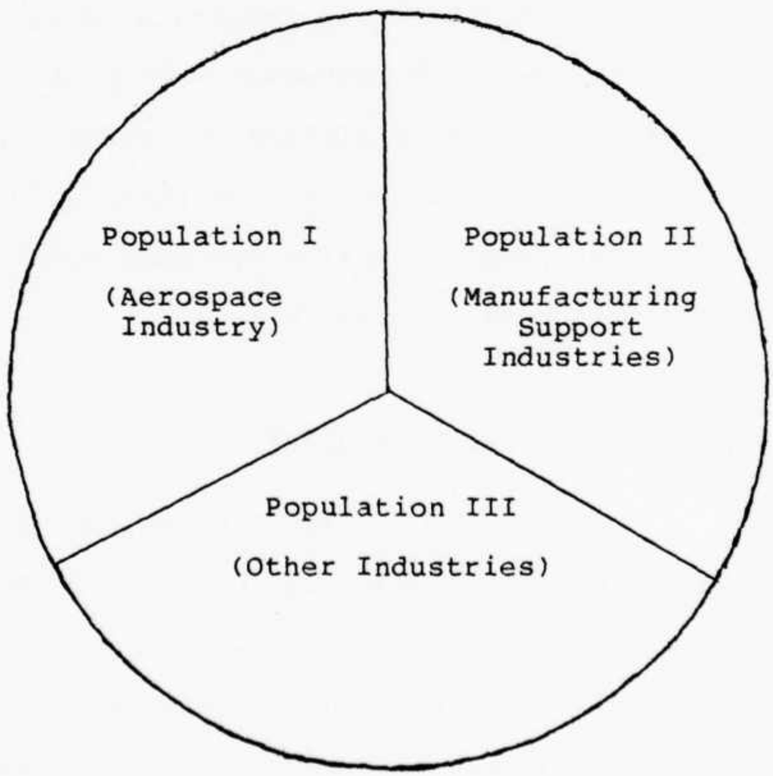

Figure 3-1 Populations Comprising the Universe for this Research

Populations of Interest

Population I is the aerospace industry which consists of the following industries as defined by the Bureau of Economic Analysis: (1) Aircraft; (2) Aircraft and Missile Engines and Engine Parts; (3) Miscellaneous Aircraft and Missile Parts; and (4) Complete Guided Missiles. The industries comprising Population II were determined by answering Research Question 1: Which manufacturing industries will be required to increase production to support a surge in aerospace defense commodity requirements?

The standard method for classifying the industries in all three populations was the 1972 Standard Industrial Classification codes used by the Census Bureau and their corresponding Input-Output codes used by the Bureau of Economic Analysis. Under the Standard Industrial Classification (SIC) system, the manufacturing industries of the economy are divided into approximately twenty major groups, 140 industrial groups, and 450 detailed industries. Each detailed industry is identified by a four-digit number. The first two digits identify the major group, the third digit identifies the industrial group, and the fourth digit identifies the detailed industry. For example, the "Aircraft" industry is assigned the number 3721. The "37" indicates it is part of the "Transportation Equipment"

major group, and the "2" signifies that within this major group it is part of the "Aircraft" industry (in this case, complete aircraft). As a further step toward identifying the production of a specific product, the Census Bureau has taken each four digit SIC category and assigned to each of its constituents a seven-digit identification number. For example,

SIC	Description
37	Transportation
372	Aircraft and Aircraft Equipment
3724	Aircraft Engines
37241	Aircraft Engines for U.S. Military Customers
3724114	Turbo-Jet and Turbo-Fan Engines for U.S. Military Customers

This research is concerned only with industries identified by four digit SIC codes because the most detailed Input-Output tables published by the Bureau of Economic Analysis are at the four-digit level (31:42-43).

Standard Industrial Classification (SIC) codes are the basis for developing the two classification schemes, industry and commodity, used in producing the Input-Output (I/O) tables. For example, an I/O industry is a grouping of establishments as classified by SIC code. An I/O commodity consists of the characteristic products of the

corresponding I/O industry. Under these definitions there is a one-to-one correspondence between industries and commodities. I/O codes were developed because SIC codes pertain to an industry's identification only, and do not account for the matching of an industry to its output (5:9). Table 3-1 summarizes the relationship between SIC and I/O codes for the aerospace industry.

Standard Industrial Classification and I/O codes are important because the industries examined in this research are defined in terms of these related codes.

TABLE 3-1

Relationship Between SIC and I/O Codes Describing the Aerospace Industry

I/O	SIC	Description
60.01	3721	Aircraft
60.02	3724, 2764	Aircraft & Missile Engine Parts
60.04	3728, 3769	Misc. Aircraft & Missile Equipment
13.01	3761	Guided Missiles

Input-Output Analysis

The methodology employed in this research is based on Input-Output analysis. Input-Output analysis is a means of quantitatively analyzing an economy in terms of the interdependence of the economy's various industries (21:49). In this research, I/O analysis is used to identify the industries comprising Population II and to forecast the increase in output from Populations I and II required to support a surge in aerospace production. These forecasts were used in answering Research Question 4.

The basis of any Input-Output analysis is the Input-Output tables. A typical I/O table shows how the output from each industry is used in the production of commodities. Simultaneously, the I/O table indicates the inputs to each commodity from each industry. A significant feature of the table is that it describes the supply and demand relationships of an economy in equilibrium. The table shows the final demand for the goods produced by the economy and the inter-industry transactions that occurred in satisfying that demand (21:30). To illustrate, consider the values illustrated in Table 3-2. Each row entry represents the dollar value of the output from a particular industry used to produce the commodity at the head of the column. For example, Industry A sold $5 billion of output to establishments producing Commodity A, $1 billion to

Commodity B, and $2 billion to Commodity C. Also, note that Industry A exported $2 billion of output, for a total output of $10 billion.

TABLE 3-2

Hypothetical Input-Output Table

(Values Recorded in Billions of Dollars)

→ Outputs / ↓ Inputs	Commodities A	B	C	Exports	Total Gross Output
Industry A	5	1	2	2	10
Industry B	2	3	15	0	20
Industry C	2	15	2	1	20
Imports	1	1	1	0	3
Total Gross Outlays	10	20	20	3	53

Each column represents the value of the inputs used in the production of the commodity from the industries listed on the left side of the table. To illustrate, consider the column for Commodity B. By reading down, it can be determined that the production of Commodity B required $1 billion of output from Industry A, $3 billion from Industry B, and $15 billion from Industry C. In addition, $1 billion of imported goods were used in the

production of Commodity B for a total of $20 billion of inputs used to produce Commodity B.

Table 3-2 is highly simplified in that only three hypothetical industries/commodities are included. The I/O tables used in this research include 496 industries and their corresponding commodities. The above illustration demonstrates how I/O tables work; however, the usefulness of the I/O tables extend beyond showing current transactions between industries and commodities. I/O tables are also useful for forecasting how an increase in demand for a commodity impacts all the industries within an economy.

Input-Output analysis can be used as a forecasting tool through the use of a table of Input-Output coefficients. Input-Output coefficients are defined as the units of a particular industry's output used in making one unit of a commodity (21:147). These I/O coefficients may be expressed in either monetary or physical units, but are normally expressed in monetary terms. A hypothetical Input-Output Coefficient table is provided in Table 3-3. The data in Table 3-3 was derived from Table 3-2. Normally, two steps are involved in calculating I/O coefficients. First, gross output is adjusted by subtracting inventory depletion during the period covered by the table to obtain adjusted gross output. In this example, this step was unnecessary because there was no beginning or ending inventory.

TABLE 3-3

Hypothetical Input-Output Coefficient Table

(Direct Inputs per Dollar of Output)

↓ Industry \ Commodity →	A	B	C
Industry A	.50	.05	.10
Industry B	.20	.15	.75
Industry C	.20	.75	.10

The second step consists of dividing all entries in each commodity's column by the adjusted gross output for that industry. In this example, the adjusted gross output of Industry A is 10. To compute the I/O coefficients for column 1, divide each industry's row value from Table 3-2 by 10 as follows:

$$(1)\quad \frac{\text{Inputs from Industry A to Commodity A}}{\text{Total gross output of Industry A}} = \frac{5}{10} = .5$$

$$(2)\quad \frac{\text{Inputs from Industry B to Commodity A}}{\text{Total gross output of Industry A}} = \frac{2}{10} = .2$$

$$(3)\quad \frac{\text{Inputs from Industry C to Commodity A}}{\text{Total gross output of Industry A}} = \frac{2}{10} = .2$$

Input-Output coefficients were not computed for imports and exports because imports were not produced by any of the three industries in the hypothetical economy and exports were not used in the production of the three commodities. Imports and exports were included in Table 3-2 to equalize total supply and total demand. The same process illustrated above was used to calculate the I/O coefficients for Industries B and C.

From Table 3-3, it can be determined that the production of one dollar's worth of Commodity A will require the following inputs:

Inputs to Commodity A from Industry A	$.50
Inputs to Commodity A from Industry B	.20
Inputs to Commodity A from Industry C	.20
Total direct inputs to Commodity A	$.90

Table 3-3 shows the dollar value of the direct inputs from each industry required in the production of one unit of each commodity; however, this does not represent the total addition to output that would result from an increase in final demand for an a commodity. The indirect effects on the economy must be considered as well as the direct effects. For example, if there was an increase in demand for cars, the direct effect of the change in demand would be an increase in the output of the automotive industry. However, there are further impacts. The increase in auto-

mobile output necessitates more steel production, which requires more chemicals, iron ore, limestone, and coal. Input-Output analysis traces this intricate chain reaction throughout all industrial sectors and measures both the direct and indirect effects on the output of each industry. The mathematics used to compute the direct and indirect effects is also complex and involves the use of matrix algebra. The following example illustrates the iterative step-by-step method used to compute the direct and indirect effects of an increase in demand for a commodity. Assume a one dollar increase in demand for Commodity A. To accomodate the increase in demand for Commodity A, Industry A would have to increase its output fifty cents (see row 1, column 1 of Table 3-3). The output of Industry B would increase by an additional $.20 ($1.00 x .20). Similarly, the output of Industry C would also increase by $.20 ($1.00 x .20). The indirect effects would continue throughout the economy as each industry interacts with every other industry. The general method of calculating the indirect effects of an increase in production involves computing a transposed inverse matrix. This could be accomplished by taking the difference between the matrix of I/O coefficients in Table 3-3 from its identity matrix.

The various Input-Output tables used in this research are subject to the following assumptions:

1. The cost relations are the same for all levels of production. This is called constant return to scales. This means that to double its output, an industry must double its inputs. This assumption ignores the economic theory of economies and diseconomies of scale; however, this assumption can be defended on the grounds that not enough is known to suggest what type of production function should be used other than simple proportions (21:97).

2. The second assumption involves the substitution of inputs in the production of a commodity (for example, substituting aluminum for steel in car manufacturing). Empirical evidence indicates that even though some substitution of inputs takes place, the substitution's impact on Input-Output coefficients is insignificant and can be ignored (23:6). This assumption was also supported by studies done by Per Sevaldsen (1976), who found that the substitution of inputs was not a major source of I/O coefficient variation (23:113).

3. The third assumption is that the Input-Output coefficients are stable over time. The most common reason cited for variations in I/O coefficients is technological change. Two types of empirical tests regarding this assumption have been performed at various times. One test consisted of direct comparisons of individual I/O coefficients over time. The other test involved comparing the forecasted operation of an economy, using

I/O coefficients from a previous year, with the actual operation of the economy. The result of both tests supported the assumption that I/O coefficients are relatively stable over time. Although much study remains to be done on the question of I/O coefficient stability, experts generally agree that the stability assumption is reasonable, especially when applied to problems requiring a general picture of the production function of a large segment of the economy (21:106-107).

The Bureau of Economic Analysis has compiled full-scale Input-Output tables of the U.S. economy for the years 1947, 1958, 1963, 1967, and 1972. The results are published in five tables, each table documenting a different aspect of inter-industry dependence:

1. The Use Table (Table 1) shows the dollar values of each commodity used by each industry in the economy.

2. The Make Table (Table 2) shows the dollar value of production of each commodity by each industry.

3. The Direct Requirements Table (Table 3) shows for each commodity the direct input required from every other industry to produce one dollar of its output.

4. The Total Requirements Table (Table 4) shows for each commodity the total direct and indirect inputs required from every other industry to accommodate a delivery of one dollar of final output.

5. The Industry Total Requirements Table (Table 5) shows the indirect and direct inputs required from the industry named at the beginning of each row to accommodate a delivery of one dollar of final output of the commodity at the head of the column (5:35-36).

The Use and Make Tables were used to answer Research Question 1.

Research Question One

Which manufacturing industries within the defense industrial base will be required to increase production due to a surge in aerospace defense commodity requirements?

Data Collection

The Bureau of Economic Analysis publication, *The Detailed Input-Output Structure of the United States Economy: The Use and Make of Commodities by Industries Tables* were used to obtain the data required to answer Research Question 1.

Data Analysis

The first step in answering Research Question 1 was to identify the commodities that would be used by the aerospace industry in its production processes. The Use of Commodities by Industries Input-Output table was used in

identifying those commodities. Table 3-4 is an example of a Use Table.

TABLE 3-4

Use of Commodities by Industries Table

(In Millions of Dollars)

↓ Commodity \ Industry →	Motor Vehicles	Semi-Conductors	Aircraft & Engines
Pig Iron	160	0	180
Steel	200	20	60
Aluminum	600	700	1,180

In Table 3-4, the commodities used by an industry can be identified by reading down the column corresponding to the industry. For example, the Aircraft Engines Industry uses the following commodities in its production: $180 million of pig iron, $60 million of steel, and $1,180 million of aluminum. Therefore, the first step in answering Research Question 1 was to identify all commodities listed under the four I/O codes, corresponding to the aerospace industry, in the Use of Commodities by Industies Input-Output table. In order to eliminate any non-essential commodities (Population III), the following criterion was used:

1. Commodities whose use by the aerospace industry was classified as "negligible" were not considered. An industry's use of a commodity is considered negligible by the Bureau of Economic Analysis if the total dollar value of that industry's purchases of a commodity is less than $100,000.

2. Only manufactured commodities were considered essential to a surge. A manufactured commodity is a finished product made through the processing of raw or unfinished goods. Although a surge in aerospace defense commodity requirements would probably result in increased demand for output from various mining, farming, construction, and service industries, these were not considered because this research focused on the surge capacity of manufacturing industries only.

3. Manufactured commodities used primarily in the peripheral support of aerospace production were not considered. Examples of these commodities include the various food processing commodities and commodities such as surgical appliances, supplies, and uniforms.

The second step in answering Research Question 1 was to identify the industries responsible for manufacturing the commodities identified in step one. This was accomplished by using the Make of Commodities by Industries Input-Output table. Table 3-5 is an example of a Make of Commodities by Industries table.

TABLE 3-5

Make of Commodities by Industries Table

(In Millions of Dollars)

Commodities	Producing Industries	Value
Pig Iron	Total	2,000
	Pig Iron	1,800
	Motor Vehicles	200
Steel	Total	3,000
	Steel	2,800
	Pig Iron	200
Aluminum	Aluminum (Total)	4,000

For the purpose of this research, only major producers were identified as industries critical to the support of a surge in aerospace production (Population II). A major producer is any industry which makes two percent or more of the total dollar value of a commodity. For example, according to Table 3-5, the total amount of pig iron produced was worth $2 trillion. Two percent of this figure is $40 million. Since the pig iron industry produced $1.8 trillion worth of pig iron and the motor vehicle industry produced $200 million worth of pig iron, both industries qualify as major producers because their production of pig iron exceeded two percent of the total amount of pig iron produced by the economy.

Research Question Two

What is the required increase in output of each manufacturing industry supporting a surge in aerospace defense commodity requirements?

Data Collection

The following Bureau of Economic Analysis and Census Bureau publications were used to collect the data required to answer Research Question 2: (1) The Detailed Input-Output Structure of the United States Economy: 1972 Total Requirements Tables; (2) The 1983 United States Industrial Outlook; and (3) The 1980 Shipments to Federal Government Agencies.

Data Analysis

For the purpose of this research, it was assumed that the DOD demand for aerospace commodities would increase by 100 percent during a surge. This figure represents a convenient base for the study and may be either an understatement or overstatement of actual demand during a surge. An advantage of Input-Output analysis is that the 100 percent figure can be easily modified, permitting analysis of various degrees of surge production. In satisfying a 100 percent increase in demand for aerospace commodities, each industry of the aerospace

defense base (Populations I and II) must increase its own output as well as relying on increased output from other industries in the economy. Determination of the degree of this reliance and the subsequent effect on each industry in the aerospace defense base required taking into account the following variables:

1. A 100 percent increase in demand due to a surge.

2. The annual total output of each industry in Populations I and II critical to the production of each aerospace commodity.

3. Total annual DOD purchases of each aerospace commodity.

4. The Input-Output coefficient (I/O) that measures the required output (in dollars) of each manufacturing industry necessary to accommodate the delivery of one dollar's worth of aerospace goods to the DOD.

The Input-Output coefficients used were derived from the Total Industry Requirements Input-Output Tables. Table 3-6 is an example of a Total Industry Requirements Table. In this table, each entry represents the direct and indirect output required from the industry named at the beginning of the row for each dollar of delivery to final demand produced by the commodity at the head of the column.

TABLE 3-6

Total Industry Requirements Direct and Indirect

(Per Dollar of Delivery of Commodities to Final Demand)

↓ Commodity \ Industry →	Motor Vehicles	Semi-Conductors	Aircraft & Engines
Pig Iron	.00005	------	.00001
Steel	.00120	.00002	.00111
Aluminum	.00097	.00327	.01677

By computing the following:

$$\frac{\text{I/O Coefficient} \times \text{Total DOD Purchases of an Aerospace Commodity}}{\text{Total Output of a Manufacturing Industry}} \times 100\%$$

for each critical manufacturing industry involved in aerospace production, the percent increase in annual total output of each industry in Populations I and II required to accommodate a 100 percent increase in demand for a given aerospace commodity was determined. For example, suppose the DOD purchases $100 million of Commodity A, and for every dollar of Commodity A delivered to the DOD, Industry B must produce ten cents of output. This yields an I/O coefficient for Industry B of ten cents. Also assume Industry B's total output is $50 million. Then, if there was a 100 percent increase in DOD annual demand for

Commodity A, Industry B would have to increase its annual production by 20 percent (see Figure 3-2).

$$\frac{.10 \times \$100\text{ m}}{\$50\text{ m}} \times 100\% = 20\%$$

Figure 3-2 Increase in Annual Production Variable

In this example, if DOD purchases of Commodity were to double, then Industry B would have to increase the value of its output by $10 million (.2 x $50 m = $10 m). In addition to measuring the percent increase in manufacturing industry output, this ratio is also the percentage of the manufacturing industry's direct and indirect output required to support the production of a given aerospace commodity. Once it was determined how much each industry in the aerospace defense base must increase its output to support a 100 percent increase in DOD demand for aerospace commod- ities, this information was used to determine each industries' vulnerability to a surge (Research Question 4).

Research Question Three

What is the excess capacity of the manufacturing industries supporting a surge in aerospace defense commodity requirements?

Data Collection

Data to answer Research Question 3 was collected from the Census Bureau's Survey of Plant Capacity, 1980. Results obtained in Research Question 1 were used to identify the critical manufacturing industries.

Data Analysis

Analysis of data for Research Question 3 consisted of subtracting the preferred capacity utilization rate for each critical manufacturing industry from 100%. Preferred capacity utilization rate or preferred capacity is an intermediate level of capacity utilization, usually between actual or current capacity and practical capacity. Preferred capacity is used because this research focuses on peacetime increases in output and the DOD may not have the ability to coerce manufacturers to produce at practical capacity during a surge. Additionally, the Department of Commerce has found that many industries' estimates of practical capacity are very inaccurate and usually overestimated, while the estimates of preferred capacity are much more realistic as to industries' actual production rates (30:B-1).

Research Question Four

What is the maximum increase in output that can be achieved by each manufacturing industry supporting a surge in aerospace defense commodity requirements and which industries are most vulnerable to a surge?

Data Collection

Data required to answer Research Question 4 was collected from the calculations performed in Research Questions 2 and 3.

Data Analysis

The first step in analyzing data for Research Question 4 consisted of computing the percentage by which each manufacturing industry can increase its production or total output. The formula used to calculate this percentage is as follows:

$$\text{Percent Maximum Increase in Output} = \frac{\text{Excess Capacity}}{\text{Preferred Capacity}} \times 100\%$$

For example, if excess capacity from Research Question 3 for a particular industry was 20 percent and the preferred capacity rate for that industry was 80 percent, then the percent maximum increase in output that could be attained by the industry would be 25 percent:

$$\text{Percent Maximum Increase in output} = 100\% \; \frac{(.20)}{(.80)} = 25\%$$

The second step was to determine the vulnerability of each manufacturing industry to a surge. This was accomplished by computing a surge ratio for each industry using the following formula:

$$\text{Surge Ratio} = \frac{\text{Percent Increase Required (from Research Question 2)}}{\text{Percent Maximum Increase in Output}}$$

For example, if a manufacturing industry must increase its output by 10 percent to support a surge in aerospace defense commodity requirements (Research Question 2) and that industry could increase its total output by 15 percent (step one, Research Question 4), then the calculated surge ratio for that industry would be 0.667, as shown below:

$$\text{Surge Ratio} = \frac{\text{Percent Increase Required}}{\text{Percent Maximum Increase in Output}} = \frac{.10}{.15} = .667$$

In other words, that industry would have to use 67 percent of its excess capacity to support a 100 percent increase in aerospace defense commodity requirements.

Ratios of 1.00 or greater indicated the particular industry had insufficient excess production capacity to support a surge in DOD aerospace commodity requirements.

Summary of Assumptions

1. All estimates supplied by the data sources reflect the real-world situation.

2. The direct and indirect technical coefficients used in Input-Output forecasting are stable over time.

3. The inputs of an industry are directly proportional to their respective commodity outputs over time.

4. Forecasts using Input-Output tables assume the level of product output determines the level of input required.

Summary of Limitations

1. The source of data is limited to the most recent statistics available from the Department of Commerce.

2. This report is limited to a study of production capacity and not production capability. Critical materials, labor availability, and other factors are not considered.

3. This research is macro-oriented to an analysis of economic industries and not individual firms.

Conclusions

This chapter focused on Input-Output analysis and its use in determining if the defense industrial base has the production capacity to surge. Through the use of the I/O tables a number of questions were answered in making the above determination.

The first key question is: What industries comprise the aerospace defense base? Secondly, What is the percent increase in output required of the aerospace and manufacturing industries to support a surge in aerospace requirements? Next, the excess capacity available to these industries was calculated and then compared to the percent increase in output required to determine if the aerospace defense base can or cannot support a surge in aerospace defense requirements.

This chapter provided the general framework for conducting the research. Chapter IV contains the results of analyzing the data using the methodology outlined in Chapter III.

CHAPTER IV

DATA ANALYSIS AND FINDINGS

Introduction

This chapter presents the data analysis and findings resulting from the application of the methodology formulated in Chapter III. The first section of this chapter describes the findings relative to Research Question 1. The second section addresses Research Question 2. The following section addresses Research Question 3. The chapter concludes with the findings relative to Research Question 4.

Research Question One

Which manufacturing industries within the defense industrial base will be required to increase production due to a surge in aerospace defense commodity requirements?

Data Collection

The data used to answer Research Question 1 was derived from the 496 industries and commodities identified by the Bureau of Economic Analysis in the 1972 Use and Make of Commodities by Industries Input-Output tables.

Data Analysis

There were two primary objectives in analyzing the data to answer Research Question 1. The first objective was to identify the manufactured commodities used by the aerospace industry in its production of aerospace equipment during a surge. The second objective was to determine which industries were responsible for manufacturing the commodities used by the aerospace industry.

The Use of Commodities by Industries tables were used to identify the manufactured commodities that would be used in the production of goods by the aerospace industry in the event of a surge. A manufactured commodity is a good produced from raw or unfinished materials. This excludes agricultural, mining, service, and construction commodities. Initially, all commodities classified as negligible were eliminated from consideration. As stated in Chapter III, the use of a commodity by an industry is considered negligible if the total dollar value of the commodity purchased by an industry is less than $100,000. Of the 496 commodities listed in the Use of Commodities by Industries tables, 341 were negligible. The 156 remaining commodities are listed in Appendix A. Next, all non-manufactured commodities were eliminated. Of the 156 previously identified commodities, thirty-nine were eliminated because they were non-manufactured commodities.

Of these thirty-nine commodities, four were agriculture, three were mining or construction commodities, and thirty-two were service commodities such as utilities, banking, or financial services. The thirty-nine non-manufactured commodities are listed in Appendix B. Finally, all manufactured commodities used in the peripheral support of production by the aerospace industry were eliminated. Examples of peripheral support commodities include tobacco products, food products, and office supplies such as envelopes, pens, pencils, and stationary. A total of forty-six commodities were identified as peripheral support items and are listed in Appendix C. This left a total of seventy manufactured commodities that could be considered critical to the production of aerospace commodities during a surge. The complete list of all seventy commodities is contained in Appendix D.

The next step in answering Research Question 1 was to identify the major producers of the seventy commodities listed in Appendix D. This was accomplished utilizing the Make of Commodities by Industries tables. A total of ninety-six industries were determined to be major producers of one or more of the seventy commodities. These industries represent the manufacturing industries which would be required to increase production due to a surge in DOD aerospace requirements and comprise Populations I and II in this research. Appendix E contains a list of all

ninety-six industries.

Research Question Two

What is the required increase in output of each manufacturing industry supporting a surge in aerospace defense commodity requirements?

Data Collection

The data used to answer Research Question 2 was obtained from the U.S. Census Bureau and the Bureau of Economic Analysis. Three categories of data were collected: (1) Input-Output coefficients for the ninety-six industries identified in Research Question 1 as critical manufacturers supporting the production of the four commodities produced by the aerospace industry; (2) total DOD purchases of aerospace commodities; (3) total output from the ninety-six manufacturing industries supporting the production of aerospace commodities. The Input-Output coefficients were obtained from the 1972 Total Requirements for Commodities and Industries tables published by the Bureau of Economic Analysis. These were the most current and complete I/O coefficient tables available. Each entry in the table represents the total direct and indirect output required from an industry to produce one dollar's worth of a particular commodity. The data on DOD purchases

of aerospace commodities was obtained from the 1980 Shipments to Federal Government Agencies report, published by the Census Bureau. Data on the total output of each of the ninety-six industries was obtained for the year 1980 from the 1983 U.S. Industrial Outlook published by the Census Bureau. Data from the year 1980 was used because it was the most complete, current, and accurate data available. Also, data for the Crude Petroleum and Natural Gas industry and the Industrial Organic and Inorganic industry was not available; therefore, these industries were eliminated from further study in this thesis.

Data Analysis

In Research Question 2, the percent total required increase in industry output for ninety-four of the industries identified in Research Question 1 was computed using the formula:

$$\frac{(\text{I/O Coefficient}) \times \begin{array}{c}(\text{DOD Purchases of an}\\ \text{Aerospace Commodity})\end{array}}{\text{Total Output of a Manufacturing Industry}} \times 100\%$$

This calculation was accomplished using Program S on the VAX-Unix computer system. The results for the ten industries requiring the largest percentage increase in demand are listed in Table 4-1. The results for all ninety-four industries are contained in Appendix F.

TABLE 4-1

Industries Requiring the Largest Percent Increase in Demand for a Surge

I/O Code	Industry Title	Percent Increase Required
13.0100	Complete Guided Missiles	91.96
60.0200	Aircraft and Missile Engines	43.64
60.0400	Misc. Aircraft and Missile Parts	33.21
50.0002	Misc. Machinery (except electrical)	22.65
38.1300	Misc. Nonferrous Castings	16.53
47.0300	Special Dies and Tools	14.68
60.0100	Aircraft	12.63
38.1400	Nonferrous Forgings	8.25
57.0200	Semiconductors	6.32
38.0900	Misc. Nonferrous Rollings & Drawings	5.83

The results of Research Question 2 are significant in that the impact of a surge on each manufacturing industry was determined. For example, the Complete Guided Missile Industry would have to increase its output by approximately 92 percent to support a surge in aerospace commodity requirements.

Research Question Three

What is the excess capacity of the critical manufacturing industries supporting a surge in aerospace defense commodity requirements?

Data Collection

The data used to answer Research Question 3 was obtained from the results of the 1980 Survey of Plant Capacity accomplished by the Census Bureau.

Data Analysis

Data analysis for Research Question 3 consisted of computing the excess capacity for the ninety-four industries identified in Research Question 1. The formula used to compute excess capacity was:

$$\text{Excess capacity} = 100\% - \text{Preferred Capacity}$$

Excess capacity for the following four industries was not computed because capacity utilization data was not available:

1. Gum and Wood Chemicals
2. Metal Heat Treating
3. Hand Tools and Saw Blades
4. Electron Tubes

Excess capacity represents the amount of unused capacity that could be used by an industry to increase its output. The more excess capacity an industry has available, the easier it would be for that industry to increase its output to support a surge. The results for the ninety industries analyzed is contained in Appendix G.

Research Question Four

What is the maximum increase in output that can be achieved by each manufacturing industry supporting a surge in aerospace defense commodity requirements and which industries are the most vulnerable to a surge?

Data Collection

The data used to answer Research Question 4 was derived from the computations performed during Research Questions 2 and 3.

Data Analysis

The analysis of data for Research Question 4 consisted of two steps. First, the maximum increase in output that could be achieved by each manufacturing industry was computed based on the amount of excess capacity available (refer to Research Question 3). This was accomplished using the formula:

$$\frac{\text{(Excess Capacity)}}{\text{(Preferred Capacity)}} \times 100\% = \begin{array}{c}\text{Percent}\\ \text{Maximum Increase}\\ \text{in Output}\end{array}$$

A complete listing of Percent Maximum Increase in Output for all industries in contained in Appendix H.

The second step in answering Research Question 4 was to compute the surge ratio for each industry to determine each industries' vulnerability to a surge in DOD aerospace commodity requirements. The formula for computing the surge ratio is:

$$\frac{\text{(Percent Increase Required)}}{\text{(Percent Maximum Increase in Output)}} = \text{Surge Ratio}$$

Table 4-2 lists the eleven industries which would be the most vulnerable to a surge in DOD aerospace commodity requirements based on their computed surge ratio. The surge ratio for all industries is contained in Appendix I.

TABLE 4-2

Eleven Most Vulnerable Industries

I/O Code	Industry Title	Surge Ratio
13.0100	Complete Guided Missiles	3.07
60.0200	Aircraft and Missile Engines	2.42
60.0400	Misc. Aircraft and Missile Parts	0.97
57.0200	Semiconductors	0.63
47.0300	Special Dies and Tools	0.54
50.0002	Misc. Machinery (except electrical)	0.40
38.1300	Misc. Nonferrous Castings	0.40
60.0100	Aircraft	0.40
38.1400	Nonferrous Forgings	0.30
56.0400	Radio & TV Communication Equipment	0.22
38.0900	Misc. Nonferrous Rolling and Drawing	0.22

Computed surge ratios of 1.0 or greater indicate the industry has insufficient excess capacity to support a surge. According to this research, the Complete Guided Missile and the Aircraft and Missile Engines and Engine Parts Industries have computed surge ratios of greater than 1.0. The surge ratio of 3.07 for the Complete Guided Missile Industry indicates the industry needs approximately three times its current excess capacity to support a surge. In addition, the Aircraft and Missile Engines and Engine Parts Industry needs approximately two and one-half times its current excess capacity to support a surge in aerospace defense commodity requirements. The research indicates all the other manufacturing industries have sufficient excess capacity to support a surge; however, the Misc. Aircraft and Missile Parts Industry would have to use approximately 95 percent of its excess capacity to support a surge. For all practical purposes, the Misc. Aircraft and Missile Parts Industry probably cannot support a surge because it is doubtful that 95 percent of the Misc. Aircraft and Missile Industry's excess capacity could be converted to defense related production.

Summary

The overall methodology outlined in Chapter III was followed in answering Research Questions 1 through 4.

The objective of Research Question 1 was to identify the manufacturing industries that would be required to increase their output due to a surge in DOD aerospace commodity requirements. A total of ninety-six industries were identified (see Appendix E) using the Use and Make of Commodities by Industries Input-Output tables.

The objective of Research Question 2 was to forecast the required increase in output from each industry needed to support a surge. The Total Requirements for Commodities by Industry Input-Output tables were instrumental in accomplishing this objective. This information is contained in Appendix F.

The objective of Research Question 3 was to determine how much excess capacity was available for an industry to increase its output. This excess capacity was computed for ninety industries and the results are contained in Appendix G.

The objective of Research Question 4 was to determine how much each industry could increase its output and to determine the vulnerability of each industry to a surge. The results of Research Question 4 are in Appendices H and I.

The conclusions and recommendations relative to these research findings are presented in Chapter V.

CHAPTER V

SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS

Introduction

The previous chapters provided the introduction and background on the research problem, a literature review, a detailed description of the research methodology, and the research findings. This chapter presents a summary of the research methodology and findings, the implications of those research findings, and recommendations for future research.

This research project examined the surge capacity of those manufacturing industries supporting the production of aerospace commodities. This research indicates most manufacturing industries have sufficient excess capacity to support a surge in the production of aerospace commodities. However, several key industries either do not have sufficient excess capacity or are highly vulnerable to a surge. A summary of the research methodology and findings are provided in the next section.

Summary of Research Methodology and Findings

The research methodology consisted of four research objectives which were accomplished by answering four research questions. The objective of Research Question 1 was to identify the manufacturing industries which would be required to increase production to support a surge in aerospace defense commodity requirements. Research Question 1 was answered using the Use and Make of Commodities by Industries Input-Output tables. The research indicated ninety-six manufacturing industries would have to increase their output in support of a surge in aerospace defense commodity requirements. These ninety-six industries comprise Populations I and II for this research. A complete listing of all industries is contained in Appendix E.

The objective of Research Question 2 was to determine the amount each manufacturing industry would have to increase its output to support a surge in aerospace defense commodity requirements. The formula,

$$\frac{\text{I/O Coefficient} \times \begin{array}{c}\text{DOD Purchases of an}\\ \text{Aerospace Commodity}\end{array}}{\text{Total Output of a Manufacturing Industry}} \times 100\%$$

was used to forecast the required percent increase in output for each of the ninety-four industries identified in Research Question 1. For example, the Complete Guided

Missile industry would have to increase its output by 92 percent to support a 100 percent increase in aerospace defense commodity requirements during a surge. The results of Research Question 2 show the impact of a surge in aerospace defense commodity requirements on all ninety-six manufacturing industries. These results are contained in Appendix F.

The objective of Research Question 3 was to determine the amount of excess capacity available for each of the ninety-six manufacturing industries identified in Research Question 1. The preferred capacity rate for each industry was analyzed to determine how much excess or unused capacity was realistically available for each manufacturing industry (refer to Appendix G).

The objective of Research Question 4 was to determine the vulnerability of each manufacturing industry to a surge in aerospace defense commodity requirements. This vulnerability was determined by computing a surge ratio for each industry using the following formula:

$$\frac{\text{Percent Increase Required}}{\text{Percent Maximum Increase in Output}} = \text{Surge Ratio}$$

Computed surge ratios of 1.0 or greater indicates the industry has insufficient excess capacity to support a surge. The research identified the Complete Guided Missile and the Aircraft and Missile Engines and Engine Parts

Industries as having insufficient excess capacity to support a surge. The calculated surge ratio of 3.07 for the Complete Guided Missile Industry indicates the Complete Guided Missile Industry requires approximately three times its current excess capacity to support a surge in aerospace defense commodity requirements. In addition, the Aircraft and Missile Engines and Engine Parts Industry needs approximately two and one-half times its current excess capacity to support a surge. According to this research, all the other manufacturing industries have sufficient excess capacity to support a surge; however, the Misc. Aircraft and Missile Parts Industry would have to use approximately 95 percent of its available excess capacity to support a surge based on its computed surge ratio of 0.95. It is highly probable that the Misc. Aircraft and Missile Parts Industry could <u>not</u> convert all its available excess capacity to defense related production; therefore, for all practical purposes, the Misc. Aircraft and Missile Parts Industry has insufficient excess capacity to support a surge. Table 5-1 lists the eleven industries most vulnerable to a surge based on their computed surge ratios. The surge ratios for all eighty-nine manufacturing industries are provided in Appendix I.

TABLE 5-1

Eleven Most Vulnerable Industries to a Surge in Aerospace Defense Commodities

Industry Title	Surge Ratio
Complete Guided Missiles	3.07
Aircraft and Missile Engines	2.42
Misc. Aircraft and Missile Parts	0.97
Semiconductors	0.63
Special Dies and Tools	0.54
Misc. Machinery (except Electrical)	0.40
Misc. Nonferrous Castings	0.40
Aircraft	0.40
Nonferrous Forgings	0.30
Radio and TV Communication Equipment	0.22
Misc. Nonferrous Rolling and Drawing	0.22

Implications of the Research

The main implication of the research is that the Complete Guided Missile, the Aircraft and Missile Engines and Engine Parts, and the Misc. Aircraft and Missile Parts Industries cannot support a surge in aerospace defense commodity requirements.

A major output of this research was the identification of the key industries that support the production of aerospace commodities. In the researchers' opinion, any industry with a surge ratio of 0.10 or greater can be considered a key industry requiring further analysis. Although a macro view of these industries indicates there is sufficient excess capacity to support a surge, a micro analysis of these key industries may prove the industries are more vulnerable to a surge than this research indicates. From an Industrial Preparedness Planning point of view, these key industries are probably where bottlenecks will occur during a surge (see Appendix I).

This research can also be used to identify industries where Air Force Industrial Planning and Modernization programs should focus. For example, San Antonio Air Logistics Center (AFLC) is considering the Ball and Roller Bearing industry for an Industrial Modernization Improvement Program (IMIP) (16). In the researchers' opinion, the Air Force could better utilize its monetary and personnel

resources by implementing an Industrial Modernization Improvement Program at one of the eleven industries listed in Table 5-1 instead of at the Ball and Roller Bearing Industry. This research determined that the Ball and Roller Bearing Industry has a computed surge ratio of 0.03, indicating plenty of excess capacity exists to support a surge.

To summarize, the best use of this research is to identify vulnerabilities in the defense industrial base and then use the information gathered for Industrial Preparedness Planning. The industries most vulnerable to a surge in aerospace defense commodity requirements have been determined, and areas where Air Force industrial improvement policy should focus have been identified.

Recommendations

Replication of this Study

The 1972 Input-Output tables used in this study were the most current available. New Input-Output tables should be published by January 1984. Replication of this research with updated data would be useful in identifying any trends in the industrial base.

Micro Analysis of Particular Industries

This research focused on the entire defense industrial base. A micro analysis of specific industries, such as the Complete Guided Missile industry, would be extremely useful in determining the surge vulnerability of specific companies supplying the Department of Defense.

Implementation into Industrial Preparedness Planning

The surge capacity of the aerospace defense base was the focus of this research. Consequently, the results of this research should be used in preparing the Production Base Analysis report which is an integral part of Industrial Preparedness Planning. Currently, the Production Base Analysis is being prepared by AFSC/PMI, Wright-Patterson AFB, Ohio. Any future research in this area should be coordinated with AFSC/PMI.

Concluding Remarks

The research indicates the Complete Guided Missile and the Aircraft and Missile Engines and Engine Parts Industries cannot support a surge in aerospace defense commodity requirements due to insufficient production capacity. The research also determined the potential vulnerability of eighty-nine industries to a surge

and recommended that the most vulnerable industries be targeted for more detailed study. These detailed studies should focus on individual companies within each industry.

Several potential research issues, such as critical materials and labor skills were not examined in this research. Undoubtedly, these issues could impact the Department of Defense's ability to surge. Hopefully, this study will serve as a catalyst for further examination of the defense industrial base and serve as one of the cornerstones of Industrial Preparedness Planning.

APPENDIX A

COMPOSITE LIST OF ALL NON-NEGLIGIBLE COMMODITIES USED BY THE AEROSPACE INDUSTRY

The following table is a list of all commodities used by the aerospace industry that are not defined as negligible in the research methodology for research question one. The list of commodities was derived from the Use of Commodities by Industries Input-Output tables by reading down the columns corresponding to the industries identified by the following I/O codes:

13.0100	Complete Guided Missiles
60.0100	Aircraft
60.0200	Aircraft & Missile Engines
60.0400	Misc. Aircraft & Missile Parts

I/O Code	Non-Negligible Commodity
2.0401	Fruits
2.0702	Greenhouse & Nursery Products
3.0000	Forestry & Fishery Products
4.0000	Agriculture, Forestry & Fishery Services
7.0000	Coal Mining
12.0201	Maintenance & Repair of Non-Farm Buildings
12.0216	Maintenance & Repair of Misc. Non-Farm Buildings
13.0100	Complete Guided Missiles
13.0500	Small Arms
13.0700	Other Ordnance and Accessories
14.0101	Meat Packing Plants
14.0102	Sausages and Other Prepared Meats
14.0103	Poultry Dressing Plants
14.2001	Confectionery Products
14.2103	Wines, Brandy, & Brandy Spirits
14.2104	Distilled Liquor (except Brandy)
15.0101	Cigarettes
15.0102	Cigars
16.0100	Broadwoven Fabric Mills
17.0100	Floor Coverings
18.0400	Apparel Made from Purchased Materials
19.0306	Misc. Fabricated Textile Products
20.0200	General Sawmills & Planning Mills
20.0901	Wood Pallets & Skids

I/O Code	Non-Negligible Commodity
20.0903	Misc. Wood Products
21.0000	Wood Containers
23.0300	Public Building Furniture
24.0200	Paper Mills (Except Building Paper)
24.0400	Envelopes
24.0500	Sanitary Paper Products
24.0701	Paper Coating & Glazing
24.0703	Die-Cut Paper & Board
24.0705	Stationary Products
24.0706	Misc. Converted Paper Products
25.0000	Paperboard Containers & Boxes
26.0200	Periodicals
26.0301	Book Publishing
26.0400	Misc. Publishing
26.0501	Commercial Printing
26.0601	Manifold Business Forms
26.0602	Blankbooks & Looseleaf Binders
26.0801	Engraving & Plate Printing
27.0100	Industrial Inorganic & Organic Chemicals
27.0300	Misc. Agriculture Chemicals
27.0401	Gum & Wood Chemicals
27.0406	Misc. Chemical Preparations
28.0100	Plastic Materials and Resins
30.0000	Paints & Allied Products
31.0100	Petroleum Refining & Misc. Petroleum Products
32.0100	Tires & Inner Tubes
32.0302	Misc. Fabricated Rubber Products
32.0400	Misc. Plastic Products
34.0302	Luggage
34.0304	Personal Leather Goods
34.0305	Misc. Leather Goods
35.0100	Glass & Glass Products (except Containers)
36.0900	Misc. Pottery Products
36.1600	Abrasive Products
36.1800	Gaskets, Packing, & Sealing Devices
36.2200	Misc. Non-Metallic Mineral Products
37.0101	Blast Furnaces & Steel Mills
37.0103	Steel Wire & Related Products
37.0200	Iron & Steel Foundries
37.0300	Iron and Steel Forgings
37.0401	Metal Heat Treating
38.0700	Copper Rolling & Drawing
38.0800	Aluminum Rolling & Drawing
38.0900	Misc. Nonferrous Rolling & Drawing
38.1000	Nonferrous Wire Drawing & Insulation
38.1100	Aluminum Castings
38.1200	Brass, Bronze, & Copper Castings
38.1300	Misc. Nonferrous Castings

I/O Code	Non-Negligible Commodity
38.1400	Nonferrous Forgings
41.0100	Screw Machine Products
41.0203	Misc. Metal Stampings
42.0201	Hand & Edge Tools
42.0202	Hand Saws & Saw Blades
42.0300	Misc. Hardware
42.0401	Plating & Polishing
42.0402	Metal Coating & Allied Services
42.0500	Misc. Fabricated Wire Products
42.0800	Pipes, Valves, & Valve Fittings
42.1100	Misc. Fabricated Metal Products
47.0100	Machine Tools, Metal Cutting Type
47.0200	Machine Tools, Metal Forming Type
47.0300	Special Dies & Tools
47.0401	Power Driven Hand Tools
47.0403	Misc. Metalworking Machinery
47.0100	Pumps & Compressors
47.0200	Ball & Roller Bearings
49.0500	Power Transmission Equipment
49.0700	Misc. General Industrial Machinery
50.0001	Carburetors, Pistons, Rings, & Valves
50.0002	Misc. Machinery (except Electrical)
53.0100	Instruments to Measure Electricity
53.0400	Motors & Generators
54.0400	Electric Housewares & Fans
55.0100	Electric Lamps
56.0100	Radio & TV Receiving Sets
56.0400	Radio & TV Communication Equipment
57.0200	Semiconductors
57.0300	Misc. Electronic Components
58.0100	Storage Batteries
58.0300	X-Ray Apparatus & Tubes
58.0400	Engine Electrical Equipment
59.0302	Motor Vehicle Parts & Accessories
60.0100	Aircraft
60.0200	Aircraft & Missile Engines and Engine Parts
60.0400	Misc. Aircraft & Missile Parts
62.0100	Engineering & Scientific Instruments
62.0200	Mechanical Measuring Devices
62.0500	Surgical Appliances & Supplies
62.0700	Watches, Clocks, & Parts
63.0100	Optical Instruments & Goods
63.0200	Ophthalmic Goods
63.0300	Photographic Equipment & Supplies
64.0101	Jewelry, Precious Metals
64.0104	Silverware & Plated Ware
64.0400	Misc. Sporting & Athletic Goods
64.0501	Pens & Mechanical Pencils

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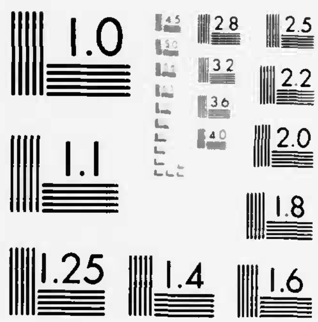
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I/O Code	Non-Negligible Commodity
64.0502	Lead Pencils & Art Goods
64.0503	Marking Devices
64.0504	Carbon Paper & Inked Ribbons
65.0100	Railroads & Related Devices
65.0200	Highway Passenger Transportation
65.0300	Motor Freight Transportation & Warehousing
65.0400	Water Transportation
65.0500	Air Transportation
65.0600	Pipelines (except Natural Gas)
65.0700	Transportation Services
66.0000	Communications (except Radio & TV)
68.0100	Electric Services (utilities)
68.0200	Gas Production & Distribution (utilities)
68.0300	Water Supply & Sanitary Services
69.0100	Wholesale Trade
69.0200	Retail Trade
70.0100	Banking
70.0200	Credit Agencies
70.0300	Security & Commodity Brokers
70.0400	Insurance Carriers
71.0200	Real Estate
72.0100	Hotels & Lodging Places
72.0200	Personal & Repair Services
73.0100	Misc. Business Services
73.0200	Advertising
73.0300	Misc. Professional Services
74.0000	Eating & Drinking Places
75.0000	Automotive Repair & Services
76.0200	Amusement & Recreation Services
77.0400	Educational Services
77.0500	Nonprofit Organizations
78.0100	U.S. Postal Services
79.0300	Other State & Local Government Services
80.0000	Noncomparable Imports
81.0000	Scrap

APPENDIX B

COMMODITIES PRODUCED BY NON-MANUFACTURING INDUSTRIES

The following table is a list of all commodities used by the aerospace industry which were produced primarily by non-manufacturing industries.

I/O Code	Non-Manufactured Commodities
	Agricultural, Forestry, and Fishery Products
2.0401	Fruits
2.0702	Greenhouse & Nursery Products
3.0000	Forestry & Fishery Products
4.0000	Agriculture, Forestry, & Fishery Services
	Mining and Construction
7.0000	Coal Mining
12.0201	Maintenance & Repair of Non-Farm Buildings
12.0216	Maintenance & Repair of Misc. Non-Farm Buildings
	Service Industries (Transportation, Communications, and Utilities)
65.0100	Railroad & Related Devices
65.0200	Highway Passenger Transportation
65.0300	Motor Freight Transportation & Warehousing
65.0400	Water Transportation
65.0500	Air Transportation
65.0600	Pipelines (except Natural Gas)
65.0700	Transportation Services
66.0000	Communications (except Radio & TV)
68.0100	Electric Services (utilities)
68.0200	Gas Production & Distribution (utilities)
68.0300	Water Supply & Sanitary Services
69.0100	Wholesale Trade
69.0200	Retail Trade
70.0100	Banking
70.0200	Credit Agencies
70.0300	Security & Commodity Brokers
70.0400	Insurance Carriers
71.0200	Real Estate
72.0100	Hotels & Lodging Places

I/O Code	Non-Manufactured Commodities
72.0200	Personal & Repair Services
73.0100	Misc. Business Services
73.0200	Advertising
73.0300	Misc. Professional Services
74.0000	Eating & Drinking Places
75.0000	Automotive Repair & Services
76.0400	Amusement & Recreation Services
77.0300	Educational Services
77.0500	Nonprofit Organizations
78.0100	U.S. Postal Services
79.0300	Other State & Local Government Services
79.0000	Noncomparable Imports
81.0000	Scrap

APPENDIX C

MANUFACTURED COMMODITIES USED IN THE PHERIPHERAL SUPPORT OF THE AEROSPACE INDUSTRY

The following table lists the commodities classified as peripheral support commodities for the purposes of this research.

I/O Code	Pheripheral Support Commodity
14.0101	Meat Packing Plants
14.0102	Sausages & Other Prepared Meats
14.0103	Poultry Dressing Plants
14.2001	Confectionery Products
14.2103	Wines, Brandy, & Brandy Spirits
14.2104	Distilled Liquor (except Brandy)
15.0101	Cigarettes
15.0102	Cigars
16.0101	Broadwoven Fabric Mills
17.0100	Floor Coverings
18.0400	Apparel Made From Purchased Materials
19.0306	Misc. Fabricated Textile Products
20.0200	General Sawmills & Planning Mills
20.0901	Wood Pallets & Skids
20.0903	Misc. Wood Products
21.0000	Wood Containers
23.0300	Public Building Furniture
24.0200	Paper Mills (except Building Paper)
24.0400	Envelopes
24.0500	Sanitary Paper Products
24.0701	Paper Coating & Glazing
24.0703	Die-Cut Paper & Board
24.0705	Stationery Products
24.0706	Misc. Converted Paper Products
25.0000	Paperboard Containers & Boxes
26.0200	Periodicals
26.0301	Book Publishing
26.0400	Misc. Publishing
26.0501	Commercial Printing
26.0601	Manifold Business Forms
26.0602	Blankbooks & Looseleaf Binders
26.0801	Engraving & Plate Printing
34.0302	Luggage
34.0304	Personal Leather Goods
34.0305	Misc. Leather Goods
36.0900	Misc. Pottery Products
54.0400	Electric Housewares & Fans

I/O Code	Pheripheral Support Commodity
64.0104	Silverware and Plated Ware
64.0400	Misc. Sporting & Athletic Goods
64.0501	Pens & Mechanical Pencils
64.0502	Lead Pencils & Art Goods
64.0503	Marking Devices
64.0504	Carbon Paper & Related Devices
62.0500	Surgical Appliances & Supplies
62.0700	Watches, Clocks, & Parts
59.0302	Motor Vehicle Parts & Accessories

APPENDIX D

MANUFACTURED COMMODITIES CRITICAL
TO THE SUPPORT OF THE AEROSPACE
INDUSTRY DURING A SURGE

The following table lists the commodities critical to the support of a surge in DOD aerospace commodity requirements.

I/O Code	Critical Commodity
13.0100	Complete Guided Missiles
13.0500	Small Arms
13.0700	Other Ordnance and Accessories
27.0100	Industrial Inorganic & Organic Chemicals
27.0300	Misc. Agriculture Chemicals
27.0401	Gum & Wood Chemicals
27.0406	Misc. Chemical Preparations
28.0100	Plastic Materials and Resins
30.0000	Paints & Allied Products
31.0100	Petroleum Refining & Misc. Petroleum Products
32.0100	Tires & Inner Tubes
32.0302	Misc. Fabricated Rubber Products
32.0400	Misc. Plastic Products
35.0100	Glass & Glass Products (except Containers)
36.1600	Abrasive Products
36.1800	Gaskets, Packing, & Sealing Devices
36.2200	Misc. Non-Metallic Mineral Products
37.0101	Blast Furnaces & Steel Mills
37.0103	Steel Wire & Related Products
37.0200	Iron & Steel Foundries
37.0300	Iron and Steel Forgings
37.0401	Metal Heat Treating
38.0700	Copper Rolling & Drawing
38.0800	Aluminum Rolling & Drawing
38.0900	Misc. Nonferrous Rolling & Drawing
38.1000	Nonferrous Wire Drawing & Insulation
38.1100	Aluminum Castings
38.1200	Brass, Bronze, & Copper Castings
38.1300	Misc. Nonferrous Castings
38.1400	Nonferrous Forgings
41.0100	Screw Machine Products
41.0203	Misc. Metal Stampings
42.0201	Hand & Edge Tools
42.0202	Hand Saws & Saw Blades
42.0300	Misc. Hardware
42.0401	Plating & Polishing
42.0402	Metal Coating & Allied Services
42.0500	Misc. Fabricated Wire Products

I/O Code	Critical Commodity
42.0800	Pipes, Valves, & Valve Fittings
42.1100	Misc. Fabricated Metal Products
47.0100	Machine Tools, Metal Cutting Type
47.0200	Machine Tools, Metal Forming Type
47.0300	Special Dies & Tools
47.0401	Power Driven Hand Tools
47.0403	Misc. Metalworking Machinery
47.0100	Pumps & Compressors
47.0200	Ball & Roller Bearings
49.0500	Power Transmission Equipment
49.0700	Misc. General Industrial Machinery
50.0001	Carburetors, Pistons, Rings, & Valves
50.0002	Misc. Machinery (except Electrical)
53.0100	Instruments to Measure Electricity
53.0400	Motors & Generators
55.0100	Electric Lamps
56.0100	Radio & TV Receiving Sets
56.0400	Radio & TV Communication Equipment
57.0200	Semiconductors
57.0300	Misc. Electronic Components
58.0100	Storage Batteries
58.0300	X-Ray Apparatus & Tubes
58.0400	Engine Electrical Equipment
60.0100	Aircraft
60.0200	Aircraft & Missile Engines & Engine Parts
60.0400	Misc. Aircraft & Missile Parts
62.0100	Engineering & Scientific Instruments
62.0200	Mechanical Measuring Devices
63.0100	Optical Instruments & Goods
63.0200	Ophthalmic Goods
63.0300	Photographic Equipment & Supplies
64.0101	Jewelry, Precious Metals

APPENDIX E

INDUSTRIES PRODUCING THE COMMODITIES CRITICAL TO THE SUPPORT OF A SURGE IN AEROSPACE COMMODITY REQUIREMENTS

This appendix contains the results of the data analysis for Research Question 1. The following is a list of industries producing the commodities (refer to Appendix D) critical to the support of a surge in DOD aerospace requirements.

I/O Code	Industry Title
13.0100	Complete Guided Missiles
13.0200	Misc. Ammunition (except Small Arms)
13.0500	Small Arms
13.0700	Other Ordnance and Accessories
24.0200	Paper Mills (Except Building Paper)
24.0300	Paperboard Mills
24.0701	Paper Coating & Glazing
27.0100	Industrial Inorganic & Organic Chemicals
27.0300	Misc. Agriculture Chemicals
27.0401	Gum & Wood Chemicals
27.0402	Adhesives & Sealants
27.0406	Misc. Chemical Preparations
28.0100	Plastic Materials and Resins
29.0202	Polishes & Sanitation Goods
30.0000	Paints & Allied Products
31.0100	Petroleum Refining & Misc. Petroleum Products
32.0100	Tires & Inner Tubes
32.0302	Misc. Fabricated Rubber Products
32.0400	Misc. Plastic Products
35.0100	Glass & Glass Products (except Containers)
36.1600	Abrasive Products
36.1700	Asbestos Products
36.1800	Gaskets, Packing, & Sealing Devices
36.2200	Misc. Non-Metallic Mineral Products
37.0101	Blast Furnaces & Steel Mills
37.0103	Steel Wire & Related Products
37.0104	Cold Finishing of Steel Shapes
37.0105	Steel Pipes & Tubes
37.0200	Iron & Steel Foundries
37.0300	Iron and Steel Forgings
37.0401	Metal Heat Treating
38.0400	Primary Aluminum
38.0700	Copper Rolling & Drawing
38.0800	Aluminum Rolling & Drawing

I/O Code	Industry Title
38.0900	Misc. Nonferrous Rolling & Drawing
38.1000	Nonferrous Wire Drawing & Insulation
38.1100	Aluminum Castings
38.1200	Brass, Bronze, & Copper Castings
38.1300	Misc. Nonferrous Castings
38.1400	Nonferrous Forgings
41.0100	Screw Machine Products
41.0203	Misc. Metal Stampings
42.0201	Hand & Edge Tools
42.0202	Hand Saws & Saw Blades
42.0300	Misc. Hardware
42.0401	Plating & Polishing
42.0402	Metal Coating & Allied Services
42.0500	Misc. Fabricated Wire Products
42.0800	Pipes, Valves, & Valve Fittings
42.1000	Metal Foil & Leaf
42.1100	Misc. Fabricated Metal Products
44.0002	Lawn & Garden Equipment
45.0300	Oilfield Machinery
47.0100	Machine Tools, Metal Cutting Type
47.0200	Machine Tools, Metal Forming Type
47.0300	Special Dies & Tools
47.0401	Power Driven Hand Tools
47.0403	Misc. Metalworking Machinery
48.0600	Misc. Special Industry Machinery
49.0100	Pumps & Compressors
49.0200	Ball & Roller Bearings
49.0500	Power Transmission Equipment
49.0700	Misc. General Industrial Machinery
50.0001	Carburetors, Pistons, Rings, & Valves
50.0002	Misc. Machinery (except Electrical)
51.0101	Electronic Computing Equipment
53.0100	Instruments to Measure Electricity
53.0400	Motors & Generators
53.0500	Industrial Controls
55.0100	Electric Lamps
55.0300	Wiring Devices
56.0100	Radio & TV Sets
56.0300	Radio & Telegraph Apparatus
56.0400	Radio & TV Communication Equipment
57.0100	Electron Tubes
57.0200	Semiconductors
57.0300	Misc. Electronic Components
58.0100	Storage Batteries
58.0200	Primary Batteries, Dry & Wet
58.0300	X-Ray Apparatus & Tubes
58.0400	Engine Electrical Equipment
59.0301	Motor Vehicles

I/O Code	Industry Title
59.0302	Motor Vehicle Parts & Accessories
60.0100	Aircraft
60.0200	Aircraft & Missile Engines & Engine Parts
60.0400	Misc. Aircraft & Missile Parts
61.0300	Railroad Equipment
62.0100	Engineering & Scientific Instruments
62.0200	Mechanical Measuring Devices
62.0300	Environmental Controls
63.0100	Optical Instruments & Goods
63.0200	Ophthalmic Goods
63.0300	Photographic Equipment & Supplies
64.0101	Jewelry, Precious Metals

APPENDIX F

TOTAL OUTPUT REQUIRED FROM EACH MANUFACTURING INDUSTRY SUPPORTING A SURGE IN AEROSPACE DEFENSE COMMODITY REQUIREMENTS

This appendix contains the results from the analysis of data for Research Question 2. Listed below is the total increase in output required from each manufacturing industry needed to support a surge in DOD aerospace commodity requirements. This was accomplished by computing the following for each of the industries:

$$\frac{(\text{I/O Coefficient} \times \begin{matrix}\text{(DOD Purchases of an}\\ \text{Aerospace Commodity)}\end{matrix} \times 100\%}{\text{Total Output of a Manufacturing Industry}}$$

Industry Title	Percent Increase Required
Crude Petroleum & Natural Gas	not available
Complete Guided Missiles	91.96
Misc. Ammunition (except Small Arms)	1.91
Small Arms	0.59
Other Ordinance & Accessories	2.35
Paper Mills (except Building Paper)	0.26
Paperboard Mills	0.29
Paper Coating and Glazing	0.51
Industrial Organic & Inorganic Chemicals	not available
Misc. Agriculture Chemicals	0.11
Gum & Wood Chemicals	0.32
Adhesives & Sealants	0.19
Misc. Chemical Preparations	0.38
Plastic Materials & Resins	0.64
Polishes & Sanitation Goods	0.09
Paints & Allied Products	0.44
Petroleum Refining & Misc. Petroleum Products	0.28
Tires & Inner Tubes	0.20
Misc. Fabricated Rubber Products	0.47
Misc. Plastic Products	0.32
Glass & Glass Products (except Containers)	0.26
Abrasive Products	0.57
Asbestos Products	0.29
Gaskets, Packing, & Sealing Devices	1.63
Misc. Non-Metallic Mineral Products	1.25

Industry Title	Percent Increase Required
Blast Furnaces & Steel Mills	1.41
Cold Finishing of Steel Shapes	1.41
Steel Wire & Related Products	0.60
Steel Pipes & Tubes	0.87
Iron & Steel Foundries	1.22
Iron and Steel Forgings	5.05
Metal Heat Treating	3.56
Primary Aluminum	0.66
Copper Rolling & Drawing	1.42
Aluminum Rolling & Drawing	1.74
Misc. Nonferrous Rolling & Drawings	5.83
Nonferrous Wire Drawing & Insulation	0.54
Aluminum Castings	4.29
Brass, Bronze, & Copper Castings	1.27
Misc. Nonferrous Castings	16.53
Nonferrous Forgings	8.25
Screw Machine Products	2.04
Automotive Stampings	0.22
Misc. Metal Stampings	0.92
Misc. Hand & Edge Tools	0.29
Hand Saws and Saw Blades	0.66
Misc. Hardware	0.88
Plating & Polishing	2.96
Metal Coating & Allied Services	0.98
Misc. Fabricated Wire Products	0.55
Pipes, Valves, & Valve Fittings	0.47
Metal Foil & Leaf	0.08
Misc. Fabricated Metal Products	0.77
Lawn & Garden Equipment	0.06
Oilfield Machinery	0.31
Machine Tools, Metal Cutting Type	3.40
Machine Tools, Metal Forming Type	0.13
Special Dies & Tools	14.68
Power Driven Hand Tools	0.12
Misc. Metalworking Machinery	0.26
Misc. Special Industry Machinery	0.60
Pumps & Compressors	1.54
Ball & Roller Bearings	0.68
Power Transmission Equipment	0.92
Misc. General Industrial Machinery	0.24
Carburetors, Pistons, Rings, & Valves	0.42
Misc. Machinery (except Electrical)	22.65
Electronic Computing Equipment	0.62
Instruments to Measure Electricity	0.06
Motors & Generators	0.70
Industrial Controls	0.30
Electric Lamps	0.14

Industry Title	Percent Increase Required
Wiring Devices	1.32
Radio & TV Receiving Sets	0.38
Radio & Telegraphic Apparatus	0.18
Radio & TV Communication Equipment	5.47
Electron Tubes	0.07
Semiconductors	6.32
Misc. Electronic Components	1.63
Storage Batteries	0.01
Primary Batteries, Dry & Wet	0.01
X-Ray Apparatus & Tubes	0.16
Engine Electrical Equipment	1.50
Motor Vehicles	0.02
Motor Vehicle Parts & Accessories	0.32
Aircraft	12.63
Aircraft & Missile Engines & Engine Parts	43.65
Misc. Aircraft & Missile Parts	33.22
Railroad Equipment	0.72
Engineering & Scientific Instruments	2.34
Mechanical Measuring Devices	0.81
Environmental Controls	0.18
Optical Instruments & Goods	0.41
Ophthalmic Goods	0.19
Photographic Equipment & Supplies	0.20
Jewelry, Precious Metals	0.18

APPENDIX G

EXCESS CAPACITY AVAILABLE FOR EACH MANUFACTURING INDUSTRY TO INCREASE ITS PRODUCTION OUTPUT

This appendix contains the results for Research Question 3. Listed below is the excess capacity available for each manufacturing industry to use in order to increase its output to support a surge in DOD aerospace commodity requirements.

Industry Title	Percent Excess Capacity
Crude Petroleum & Natural Gas	not available
Complete Guided Missiles	23
Misc. Ammunition (except Small Arms)	59
Small Arms	36
Other Ordinance & Accessories	26
Paper Mills (except Building Paper)	4
Paperboard Mills	7
Paper Coating and Glazing	17
Industrial Organic & Inorganic Chemicals	not available
Misc. Agriculture Chemicals	33
Gum & Wood Chemicals	not available
Adhesives & Sealants	27
Misc. Chemical Preparations	14
Plastic Materials & Resins	23
Polishes & Sanitation Goods	19
Paints & Allied Products	31
Petroleum Refining & Misc. Petroleum Products	20
Tires & Inner Tubes	18
Misc. Fabricated Rubber Products	29
Misc. Plastic Products	22
Glass & Glass Products (except Containers)	27
Abrasive Products	17
Asbestos Products	30
Gaskets, Packing, & Sealing Devices	25
Misc. Non-Metallic Mineral Products	25
Blast Furnaces & Steel Mills	20
Cold Finishing of Steel Shapes	25
Steel Wire & Related Products	30
Steel Pipes & Tubes	25
Iron & Steel Foundries	35
Iron and Steel Forgings	41
Metal Heat Treating	not available
Primary Aluminum	12

Industry Title	Percent Excess Capacity
Copper Rolling & Drawing	25
Aluminum Rolling & Drawing	not available
Misc. Nonferrous Rolling & Drawings	21
Nonferrous Wire Drawing & Insulation	24
Aluminum Castings	31
Brass, Bronze, & Copper Castings	36
Misc. Nonferrous Castings	29
Nonferrous Forgings	22
Screw Machine Products	20
Automotive Stampings	33
Misc. Metal Stampings	29
Misc. Hand & Edge Tools	35
Hand Saws and Saw Blades	not available
Misc. Hardware	28
Plating & Polishing	36
Metal Coating & Allied Services	45
Misc. Fabricated Wire Products	27
Pipes, Valves, & Valve Fittings	23
Metal Foil & Leaf	22
Misc. Fabricated Metal Products	7
Lawn & Garden Equipment	43
Oilfield Machinery	6
Machine Tools, Metal Cutting Type	24
Machine Tools, Metal Forming Type	10
Special Dies & Tools	21
Power Driven Hand Tools	26
Misc. Metalworking Machinery	10
Misc. Special Industry Machinery	27
Pumps & Compressors	19
Ball & Roller Bearings	21
Power Transmission Equipment	35
Misc. General Industrial Machinery	27
Carburetors, Pistons, Rings, & Valves	34
Misc. Machinery (except Electrical)	36
Electronic Computing Equipment	18
Instruments to Measure Electricity	10
Motors & Generators	28
Industrial Controls	28
Electric Lamps	34
Wiring Devices	35
Radio & TV Receiving Sets	30
Radio & Telegraphic Apparatus	17
Radio & TV Communication Equipment	20
Electron Tubes	not available
Semiconductors	9
Misc. Electronic Components	21
Storage Batteries	11

Industry Title	Percent Excess Capacity
Primary Batteries, Dry & Wet	31
X-Ray Apparatus & Tubes	33
Engine Electrical Equipment	35
Motor Vehicles	47
Motor Vehicle Parts & Accessories	43
Aircraft	24
Aircraft & Missile Engines & Engine Parts	15
Misc. Aircraft & Missile Parts	26
Railroad Equipment	26
Engineering & Scientific Instruments	16
Mechanical Measuring Devices	18
Environmental Controls	12
Optical Instruments & Goods	14
Ophthalmic Goods	20
Photographic Equipment & Supplies	15
Jewelry, Precious Metals	24

APPENDIX H

MAXIMUM INCREASE IN OUTPUT ATTAINABLE FOR EACH MANUFACTURING INDUSTRY SUPPORTING A SURGE IN AEROSPACE DEFENSE REQUIREMENTS

This appendix contains information regarding the increase in output that can be attained by each manufacturing industry based on the amount of excess capacity available. Listed below are the manufacturing industries and the percent maximum increase in output that each industry can produce to support a surge in DOD aerospace commodity requirements. For example, if an industry is currently producing $100 worth of goods utilizing 50 percent of its preferred capacity, then the industry can increase its output by 100 percent to $200 by utilizing the remaining 50 percent of its available excess capacity.

Industry Title	Percent Increase in Output
Crude Petroleum & Natural Gas	not available
Complete Guided Missiles	30
Misc. Ammunition (except Small Arms)	47
Small Arms	67
Other Ordinance & Accessories	35
Paper Mills (except Building Paper)	4
Paperboard Mills	8
Paper Coating and Glazing	20
Industrial Organic & Inorganic Chemicals	not available
Misc. Agriculture Chemicals	49
Gum & Wood Chemicals	not available
Adhesives & Sealants	37
Misc. Chemical Preparations	16
Plastic Materials & Resins	30
Polishes & Sanitation Goods	23
Paints & Allied Products	45
Petroleum Refining & Misc. Petroleum Products	25
Tires & Inner Tubes	22
Misc. Fabricated Rubber Products	41
Misc. Plastic Products	28
Glass & Glass Products (except Containers)	37

Industry Title	Percent Increase in Output
Abrasive Products	20
Asbestos Products	43
Gaskets, Packing, & Sealing Devices	33
Misc. Non-Metallic Mineral Products	33
Blast Furnaces & Steel Mills	25
Cold Finishing of Steel Shapes	33
Steel Wire & Related Products	43
Steel Pipes & Tubes	33
Iron & Steel Foundries	54
Iron and Steel Forgings	69
Metal Heat Treating	not available
Primary Aluminum	14
Copper Rolling & Drawing	33
Aluminum Rolling & Drawing	not available
Misc. Nonferrous Rolling & Drawings	27
Nonferrous Wire Drawing & Insulation	39
Aluminum Castings	45
Brass, Bronze, & Copper Castings	55
Misc. Nonferrous Castings	41
Nonferrous Forgings	28
Screw Machine Products	25
Automotive Stampings	49
Misc. Metal Stampings	41
Misc. Hand & Edge Tools	54
Hand Saws and Saw Blades	not available
Misc. Hardware	39
Plating & Polishing	56
Metal Coating & Allied Services	82
Misc. Fabricated Wire Products	37
Pipes, Valves, & Valve Fittings	30
Metal Foil & Leaf	28
Misc. Fabricated Metal Products	8
Lawn & Garden Equipment	75
Oilfield Machinery	6
Machine Tools, Metal Cutting Type	32
Machine Tools, Metal Forming Type	11
Special Dies & Tools	27
Power Driven Hand Tools	35
Misc. Metalworking Machinery	11
Misc. Special Industry Machinery	37
Pumps & Compressors	23
Ball & Roller Bearings	27
Power Transmission Equipment	54
Misc. General Industrial Machinery	37
Carburetors, Pistons, Rings, & Valves	52
Misc. Machinery (except Electrical)	56
Electronic Computing Equipment	22

Industry Title	Percent Increase in Output
Instruments to Measure Electricity	11
Motors & Generators	39
Industrial Controls	39
Electric Lamps	52
Wiring Devices	54
Radio & TV Receiving Sets	43
Radio & Telegraphic Apparatus	20
Radio & TV Communication Equipment	25
Electron Tubes	not available
Semiconductors	10
Misc. Electronic Components	27
Storage Batteries	12
Primary Batteries, Dry & Wet	45
X-Ray Apparatus & Tubes	49
Engine Electrical Equipment	54
Motor Vehicles	89
Motor Vehicle Parts & Accessories	75
Aircraft	32
Aircraft & Missile Engines & Engine Parts	18
Misc. Aircraft & Missile Parts	35
Railroad Equipment	35
Engineering & Scientific Instruments	19
Mechanical Measuring Devices	22
Environmental Controls	14
Optical Instruments & Goods	16
Ophthalmic Goods	25
Photographic Equipment & Supplies	18
Jewelry, Precious Metals	32

APPENDIX I

COMPUTED VULNERABILITY OF EACH MANUFACTURING INDUSTRY TO A SURGE IN AEROSPACE DEFENSE COMMODITY REQUIREMENTS

This appendix contains the final results for Research Question 4. Specifically, the vulnerability of the eighty-nine manufacturing industries to a surge in DOD aerospace commodities requirements is addressed. Listed below are the manufacturing industries and their corresponding surge ratio. The industries are ranked according to their computed surge ratio (highest to lowest).

The surge ratio is the ratio of the percent total required increase in output from each manufacturing industry (refer to Research Question 2) over the maximum percent that each manufacturing industry can increase its output given the amount of excess capacity available. For example, suppose, in Research Question 2, it was determined that Industry A would have to increase its output by 50 percent in order to support a 100 percent increase in the production of Commodity B. Also, suppose that in Research Question 4, it was found that Industry A could increase its output by 25 percent. By calculating the surge ratio, $\frac{50}{25} = 2$, one can determine that Industry A <u>cannot</u> support a 100 percent increase in output of Commodity B due to a lack of production capacity. The computed surge ratio of two indicates Industry A must double its excess capacity to support a 100 percent increase in Commodity B. Any surge ratio greater than one means insufficient excess capacity exists to support a surge.

Industry Title	Computed Surge Ratio
Complete Guided Missiles	3.07
Aircraft & Missile Engines & Engine Parts	2.42
Misc. Aircraft & Missile Parts	0.97
Semiconductors	0.63
Special Dies & Tools	0.54
Misc. Machinery (except Electrical)	0.40
Misc. Nonferrous Castings	0.40
Aircraft	0.40
Nonferrous Forgings	0.30
Radio and TV Communication Equipment	0.22
Misc. Nonferrous Rolling & Drawing	0.22
Engineering & Scientific Instruments	0.12
Machine Tools, Metal Cutting Type	0.11
Misc. Fabricated Wire Products	0.10
Aluminum Castings	0.10
Small Arms	0.09
Screw Machine Products	0.08
Iron & Steel Forgings	0.07
Pumps and Compressors	0.07
Other Ordnance & Accessories	0.07
Paper Mills (except Building Paper)	0.06
Misc. Electronic Components	0.06
Blast Furnace & Steel Mills	0.06
Plating & Polishing	0.05
Oilfield Machinery	0.05
Gaskets, Packing, & Sealing Devices	0.05
Primary Aluminum	0.05
Copper Rolling & Drawing	0.04
Misc. Ammunitions (except Small Arms)	0.04
Misc. Nonmetallic Mineral Products	0.04
Mechanical Measuring Devices	0.04
Paperboard Mills	0.04
Cold Finishing of Steel Shapes	0.03
Abrasive Products	0.03
Electronic Computing Equipment	0.03
Engine Electrical Equipment	0.03
Optical Instruments & Lenses	0.03
Steel Pipes & Tubes	0.03
Ball & Roller Bearings	0.03
Misc. Chemical Preparations	0.02
Wiring Devices	0.02
Misc. Metalworking Machinery	0.02
Misc. Hardware	0.02

Industry Title	Computed Surge Ratio
Misc. Metal Stampings	0.02
Brass, Bronze, & Copper Castings	0.02
Iron & Steel Foundries	0.02
Plastic Materials & Resins	0.02
Railroad Equipment	0.02
Motors & Generators	0.02
Steel Wire & Related Products	0.02
Power Transmission Equipment	0.02
Misc. Special Industry Equipment	0.02
Pipes, Valves, & Valve Fittings	0.02
Paper Coating & Glazing	0.02
Misc. Fabricated Wire Products	0.02
Nonferrous Wire Drawing & Insulating	0.01
Environmental Controls	0.01
Misc. Fabricatd Rubber Products	0.01
Metal Coating & Allied Services	0.01
Misc. Plastic Products	0.01
Petroleum Related Products	0.01
Machine Tools, Metal Forming Type	0.01
Photographic Equipment & Supplies	0.01
Paints & Allied Products	0.01
Tires & Inner Tubes	0.01
Radio & TV Receiving Sets	0.01
Radio & Telegraphic Apparatus	0.00
Ophthalmic Goods	0.01
Industrial Controls	0.01
Carburetors, Pistons, Valves, & Rings	0.01
Glass & Glass Products (except Containers)	0.01
Asbestos Products	0.01
Jewelry, Precious Metal	0.01
Misc. General Industrial Equipment	0.01
Adhesives & Sealants	0.01
Automotive Stampings	0.01
Instruments to Measure Electricity	0.01
Misc. Hand & Edge Tools	0.01
Motor Vehicle Parts & Accessories	0.01
Polishes and Sanitation Goods	0.00
Power Driven Hand Tools	0.00
Metal Foil & Leaf	0.00
X-Ray Apparatus & Tubes	0.00
Electric Lamps	0.00
Misc. Agriculture Chemicals	0.00
Lawn & Garden Equipment	0.00
Storage Batteries	0.00
Primary Batteries, Wet & Dry	0.00
Motor Vehicles	0.00
Electron Tubes	--

Industry Title	Computed Surge Ratio
Crude Petroleum & Natural Gas	--
Industrial Inorganic & Organic Chemicals	--
Gum & Wood Chemicals	--
Metal Heating Treating	--
Aluminum Rolling & Drawing	--
Hand Saws & Saw Blades	--

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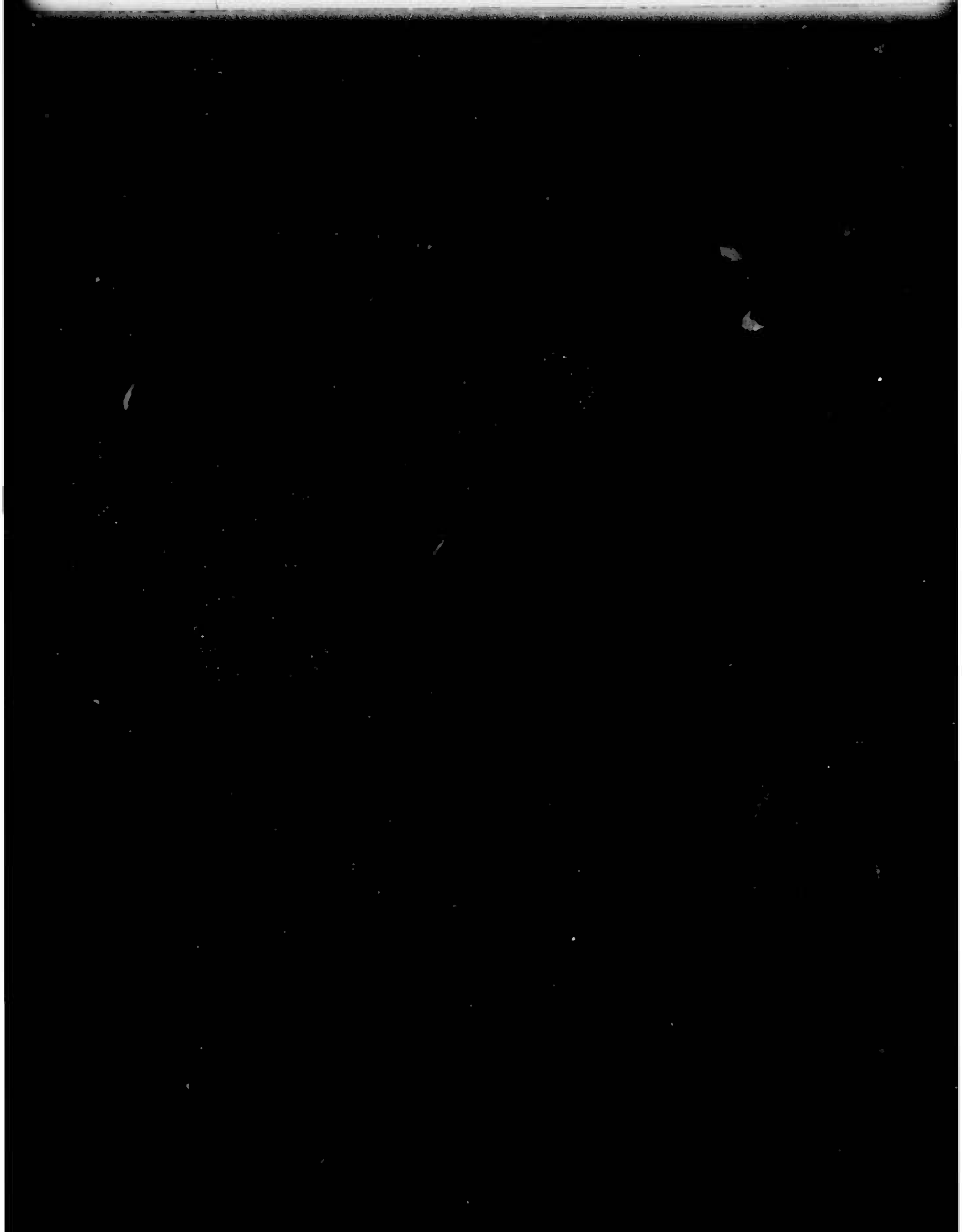
Misc. Machinery (except Electrical)	56
Electronic Computing Equipment	22



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